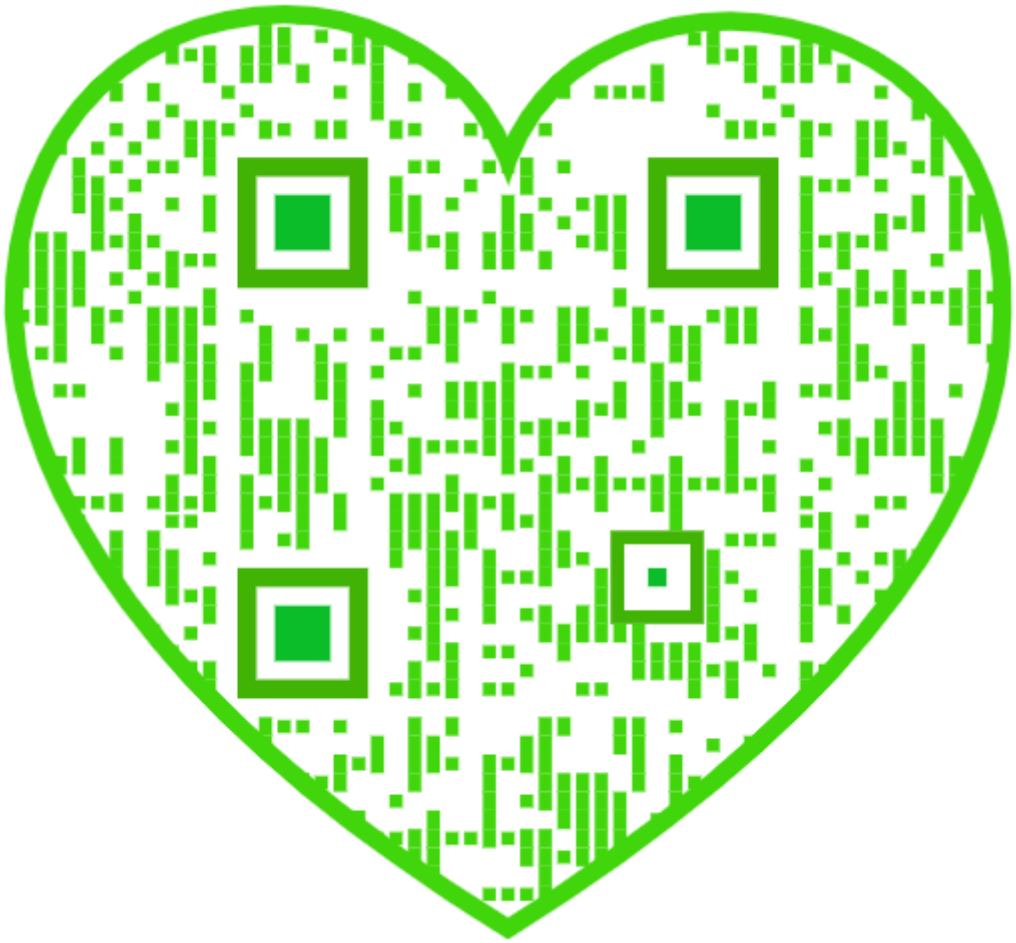
Kelly

THE PREFABRICATION OF HOUSES



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2006

To Reed Kelso.

In deep appreciation and gratitude for your pioneering efforts in developing the Gunnison Home and Organization — and for the masterly manner in which you built up the Post War II Gunnison Dealer Organization and the Gunnison Homes Institute. All that in addition to your earlier effort in creating Valley View Court which, I maintain, was the greatest boost to the industry during the struggling years of 1937-38.

Ivy Gunnison

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THE PREFABRICATION OF HOUSES

A Study by the Albert Farwell Bemis Foundation of the Prefabrication Industry in the United States

By BURNHAM KELLY

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". . . he that strives to touch the starres,
oft stombles at a strawe"

EDMUND SPENSER
The Shepheardes Calender

Foreword

Fourteen years ago Albert Farwell Bemis completed his important trilogy on housing, published under the general title, *The Evolving House.* The final volume of this work, *Rational Design,* was largely devoted by Mr. Bemis to exposition of his modular theory, a theory which has since found wide application in the standardization of the dimensions of building materials.

The volume also contained a long appendix which I had the privilege of putting together and which at the time of publication was perhaps the largest single compilation of the efforts of various people over the years to arrive at a design for a factory-made house.

This appendix had serious defects, and the greatest of these was one common to the times, and one from which prefabrication has not yet escaped, that is, an inordinate interest in the engineering detail of the various proposals and an inadequate interest in all the other factors which might determine success or failure.

It is true that I attempted to correct this by publishing a list of questions which a hopeful prefabricator ought conscientiously to ask himself, but even these were heavily weighted on the side of design; and, though the individual descriptions did attempt to state many facts about each proposal, these facts were obtained from the armchair, so to speak, by using the replies sent in by the sponsors themselves. Experience has shown that sponsors are universally overoptimistic.

In the process of putting together this appendix, we naturally accumulated very substantial files of information. Mr. Bemis died in 1936, while his last volume was in the press; in 1938 Mrs. Bemis and her children established the Albert Farwell Bemis Foundation for housing research at the Massachusetts Institute of Technology. I had the honor to be the first Director. The information files came with the Foundation to M.I.T.

We had scarcely put together a working team when war came along and scattered it. In 1945 when some of us came back I was soon succeeded as Director by Burnham Kelly, who is the author of this book.

The interest in prefabrication was even more intense in the postwar period than it had been in the thirties. The files of the Bemis Foundation, though far from complete, were certainly among the largest in the country. The Foundation was frequently sought out by visitors, especially from abroad, who were seeking the truth about a business concerning which many half-truths or untruths were being said. In the light of this interest it soon became apparent that we needed much more information than we had, and of many different kinds, if an approximation to truth was going to be possible. It was also clear that much of this information could be obtained only by personal observation in the communities of the various entrepreneurs. It was this that started the Foundation to collecting more information by the process of field survey. It is the results of this field survey and the conclusions which may be drawn from them that the reader will find in this book.

Prefabrication, or the factory manufacture of houses, means many different things to different people. To some it is a variegated Golconda; the seeker for a house who finds that what he does not want costs more than what he wants to pay imagines that houses produced like automobiles or radios ought to be nearer his heart's desire; the entrepreneur imagines that he may be another Ford; the manufacturer of conventional building materials wonders whether he may not sell more of these by making them into some sort of package; the manufacturer of building equipment fancies that he may have all his latest apparatus in every house if he provides the package as well; a national president faced with depression may look to it as a new industry to lead from the morass; the opponent of subsidized housing may see a chance of arresting the tide if the cost of the housing unit can be materially reduced through factory methods. And all these hopes would have some justification if only the successful commercial manufacture of houses on a large scale could be achieved.

To others prefabrication is a source of fear and not of hope. The investor who is overcommitted in loans on real estate may legitimately wonder whether a sudden and significant downward shift in the cost of a house may not be disastrous; the building-trades laborer who pursues an antiquated craft with little of the joy of the onetime building craftsman may fear technological unemployment; the realtor who is not wise about real estate and is really nothing more than a peddler of some one else's property may have the same apprehension; and to a certain extent every present homeowner can share the fear of the investor although he may display it in an attitude towards the appearance of the product. All these vested interests are precisely the same in kind as those which have historically opposed every other innova-

tion (and which in the long run have always lost out). And the methods they use to oppose are fundamentally the same—the marshalling of adverse public opinion, the imposition of restrictive legislation, the technique of the strike. All their fears would have some justification if successful commercial manufacture on a large scale came about too suddenly.

But there are others, too, who are interested. There are sincere engineers and inventors who think that by application of their personal talents something socially important (and personally profitable) will come about. There are *blageurs* who are more interested in personal publicity than in a successful house and who, therefore, propose preposterous but fascinating fantasies. These take the eyes of publishers who have magazines rather than realities to retail, and they serve as interesting table conversation among the *avant garde;* unfortunately, they also raise hopes, only to shatter them again. This has been going on for a long time—too long.

It is of course always possible that some miraculous invention may open the gates which have so long resisted all attack, but this seems very unlikely. It has seemed to some that enormous investments of capital might offer the key, but that this in itself is not enough seems witnessed by some recent events. Some of us have hoped that a thriving, if small and unspectacular, manufacturer of fairly conventional houses, might, step by step, year by year, introduce the improvements in structure and materials and the efficiencies in design and production which would gradually drive down the cost and increase the market. But none of these things has yet come about.

I have spent so much discussion on what is after all a foreword largely as an easy way of saying what was wrong with my appendix of 1936 and of appreciating the corrections which I believe the reader will find in the present volume. It should be of interest to all those I have cited as having hopes or fears, to houseseeker and houseowner, to investor and realtor, to manufacturer looking hopefully beyond his own range, to building-trades laborer, to politician, and to statesman. At the most it may suggest how really to open the gate; at the least it will suggest how *not* to.

Successful factory manufacture of houses will depend upon a first-rate combination of managerial brains, financial acumen, engineering skill, aesthetic sensibility, social consciousness, and marketing wisdom. A study of the state of the art stands therefore at the crossroads of the applied physical and social sciences, an appropriate place for a teacher at M.I.T. to stand.

It is therefore a pleasure to say of this book by Mr. Kelly that I believe it has an important message to tell. I am gratified that he has done such a good job; and I think that Mr. Bemis, if he were alive, would be gratified, too.

JOHN ELY BURCHARD

Cambridge, Massachusetts
January, 1951

Preface

In the hope of serving readers of widely varying interests, this book has been divided into three parts. The first part is editorial in nature. It includes a brief history of the prefabrication of houses in the United States, a summary of the present state of the industry, and some speculation regarding its future. This material represents the best judgment of the Bemis Foundation, and, while it has a broad basis in fact, we have not hesitated to generalize, to extrapolate, and to present our unsupported opinions.

The second part of the book can better be described as reportorial. Here the industry has been treated as nearly as possible on a factual basis, with opinions given only when there is no other way by which a trained observer may record the facts. This material approaches the status of working data, and we hope that it may be used by men wiser than we to correct the conclusions reached in the first part.

The third part of the book is a collection of more detailed appendix material, not suitable for inclusion in the text, but likely to prove useful to many readers.

We have emphasized throughout the book the importance of treating the prefabrication of houses as a complete pattern of operations of which management, design, procurement, production, and marketing are the major subdivisions. Indeed, the material in the second part is so organized that the reader will have to look under each of these subdivisions in order to gather all the information on any one company. To have organized the material by companies, while maintaining this emphasis, would have meant endless repetition and a doubling of the bulk of the book.

Far more important, the full understanding of each subdivision of the pattern of operations might have been lost in a company-by-company analysis. We hope to make it abundantly clear that the company which has good design must also have good management, intelligent procurement, efficient production, and effective marketing to have any chance of real success.

A large part of the material on which the book is based was collected over a period of years in the files of the Bemis Foundation and its antecedent, Bemis Industries, Inc. The backbone of this study, however, was a detailed survey of prefabricators in the United States which was made by the Foundation in 1946 and 1947 and supplemented by an extended field survey by our Research Assistant, Herbert S. Heavenrich, Jr. At that time, there were in the field more prefabricators and would-be-prefabricators than there had been ever before or have been since. With a postwar housing boom in view, and with the encouragement of government and financial circles, many of those whose ingenuity and productive skill had proved valuable in the war effort determined to invade the field of housing. The high noon of this effort occurred, by chance, just at the time of our survey. Through good fortune, therefore, we are able to present an analysis of some general historical value.

We are also fortunate in that relatively few new developments of importance have taken place during the period required for the analysis of our information and the preparation of this book. Recent news in prefabrication has consisted largely of the failures of some companies and the continuing development of others whose character was already well established in 1947.

The work of writing this book was shared in large part by the several Research Assistants of the Bemis Foundation.

The original organization of the field survey and the first assembly of the material in the second part were the work of Herbert S. Heavenrich, Jr. William F. Blitzer helped to develop the final form of the book and wrote drafts of many major sections of it, including in the first part the chapters on the history and present state of the industry, and in the second part the chapters on management, procurement, and production. Cyril C. Hermann put together the material on marketing, and John F. Falkenberg and Barbara W. Atchley assisted in the final editing process.

Many of the concepts which are developed in this book are those of John E. Burchard, who was Director of the Bemis Foundation when this study was started, and whose special knowledge and experience in the field have been of great value to us. Although we have made many references to his writings, it would not be possible by such means to acknowledge the degree to which we have benefited from his insight.

Our debt to those working in the field, whether as actual producers of houses or in collateral positions, will be evident throughout the

book. We should like to express our deepest gratitude here, however, for the friendly cooperation and intelligent criticism which they have offered us from the start.

BURNHAM KELLY

Cambridge, Massachusetts
January, 1951

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Part I.

Chapter 1

DEFINITIONS

The term "prefabrication" has often been loosely applied to any type of novel construction or to any method of building which differs in some significant respect from conventional construction. This stems from the plain truth that it is a difficult term to define, as can be shown by a consideration of some of the definitions which have been attempted.

One of the most general definitions, and one of the most official, is the following:

A prefabricated home is one having walls, partitions, floors, ceilings, and/or roof composed of sections or panels varying in size which have been fabricated in a factory prior to erection on the building foundation. This is in contrast to the conventionally built home which is constructed piece by piece on the site.[1]

Other writers try to be more specific:

. . . It is a question of degree. To oversimplify, and to look a bit into the future, if you *shove* and *snap* a product into place in the field, that is prefabrication. If you mix, cut, spread, fit, and patch—that's not prefabrication. If the field operation is essentially *assembly,* rather than *manufacture,* you have prefabrication. A brick and plaster wall, of course, employs manufactured ingredients, but such a wall is really manufactured in the field.

The amount of scrap and waste that must be cleaned up and removed from a building site may be taken as a rough index of the degree of prefabrication employed in any given building operation, since waste results principally from a manufacturing process, not an assembly process.[2]

Or are content to be more general:

. . . a movement to simplify construction by increasing the proportion of work completed before erection.[3]

And a few have been driven to extreme conclusions:

Prefabrication is a state of mind.[4]

[1] *Prefabricated Homes,* Commercial Standard CS125-47, 2nd ed., Prefabricated Home Manufacturers' Institute and U. S. Department of Commerce (Washington, 1947), p. 1.

[2] Howard T. Fisher, "Prefabrication. What Does It Mean to the Architect?" *Journal of The American Institute of Architects,* X (November 1948), 220.

[3] Quoted in *Proceedings, American-Soviet Building Conference* (held under the auspices of the Architects Committee of the National Committee of American-Soviet Friendship in cooperation with the New York Chapter of the American Institute of Architects; published in collaboration with *The Architectural Forum,* 1945), p. 43.

[4] Robert W. McLaughlin, quoted in *Proceedings, American-Soviet Building Conference,* p. 43.

From these definitions it can be seen that, in general usage, "prefabricated" construction is "unconventional," but not all "uncc ventional" construction is "prefabricated." Secondly, there may said to be various degrees of prefabrication, of which precutting mig be one, the fabrication of panels another, the construction of volun enclosing sections a third, and the manufacture of a complete mob dwelling unit probably the ultimate.

For our part, we shall attempt no general definitions of the ter Indeed, it is a major argument of this book that the distinction b tween prefabricated and conventional construction may well becor meaningless within the next few decades. Nevertheless, it is tr that this study is concerned primarily with those companies whi are organized to manufacture and in some degree to assemble *off t site* one or more of the basic components of a house, such as found tions, floors, walls and partitions, ceilings, and roofs.

Some of the houses produced in this manner are completely conve tional in final construction; it is only the process by which they a manufactured and assembled which distinguishes them from t product of the local builder. A large operative builder, developi raw land, making bulk purchases of materials and equipment, a building 200 or more houses at one time with work crews which mo from house to house performing highly specialized functions, may the end offer for sale houses which are far less conventional than thc of a prefabricator.

In this study, the operative builder is distinguished from the pr fabricator because his houses are manufactured and assembled large *on the site,* but attention is called to him because of the efficiency some of his methods. In the long run he is to be considered not much a competitor of the prefabricator as a potentially good custom

Part I.

Chapter 2

THE DEVELOPMENT OF THE INDUSTRY

This historical study is concerned with prefabrication—and almost exclusively with prefabrication in the United States as an industry, rather than as a trend or movement. It is written from the point of view of economic history rather than of technical history; that is, prefabrication is treated more as an industrial development than as a succession of ideas about design. The latter subject has been very well covered elsewhere.[1] This study will concern itself with the extent to which these technical ideas were realized in production and the factors which led to their abandonment or adoption. Thus it is not so much a discussion of invention—the disclosure of a new method of achieving some technical objective—as it is of innovation—the commercial introduction of a new or improved product or process.

I. Before 1900: Beginnings

A. First Traces in America

A search for the earliest historical evidences of prefabrication would lead us back to the burnt clay bricks of the Mesopotamian civilizations, many centuries before the Christian era—perhaps further. For our purposes, however, it will suffice to know that as early as 1624 the English brought with them to Cape Ann a panelized house of wood for use by the fishing fleet and that this house was subsequently disassembled, moved, and reassembled several times.[2] In 1727 two

[1] Albert Farwell Bemis and John Burchard, 2nd, *The Evolving House:* Vol. III, *Rational Design* (Cambridge: The Technology Press, 1936).

Alfred Bruce and Harold Sandbank, *A History of Prefabrication* (Raritan, N. J.: The John B. Pierce Foundation, 1943).

Housing Production II, or The Application of Quantity Production Technique to Building: Some Technical History and Considerations, Second Report of the Committee for the Industrial and Scientific Provision of Housing (London, 1943).

D. Dex Harrison, J. M. Albery, M. W. Whiting, *A Survey of Prefabrication* ([London]: Ministry of Works, 1945). This survey of prefabrication designs is among the most complete of its type. Frequent reference to it is made in this book.

[2] Charles E. Peterson, "Early American Prefabrication," *Gazette des Beaux-Arts,* XXXIII (January 1948), 38.

houses "'all cut to be erected'" [3] were exported from New Orleans to the West Indies, and there are other signs of the use of prefabrication throughout the next 100 years as a means of providing persons with shelter immediately on their arrival at a new settlement.[4]

B. Early Prefabrication in Cast Iron

Perhaps the earliest metal prefabricated house was that built some time before 1830 for the lockkeeper at Tipton Green, Staffordshire, England. The walls were of flanged vertical cast-iron panels, bolted together, painted on the exterior and lathed and plastered on the interior.[5] Cast iron was prominent in a number of other early experiments in prefabrication. Watt and Boulton in England began erecting their cast-iron framed factory buildings in 1801,[6] and in America during the forties and fifties cast-iron columns and repetitive elements of cast iron and glass were used, respectively, for frame and enclosure, as seen notably in the façades of the commercial buildings by James Bogardus.[7] The use of cast iron in prefabrication reached a spectacular climax in the Crystal Palace, built in Hyde Park, London, in 1851. Joseph Paxton based the design of this building on a relatively few mass-produced elements: glass panes, wood frames in which these were set, and cast- and wrought-iron columns and girders which were bolted together at the site to form the framework.[8] Proclaimed the largest single building the world had yet seen, it was erected in a mere four months,[9] and, demountable, it was later moved to Sydenham where it was re-erected. The Crystal Palace was a marvel for the light and airy quality of its structure, in some respects a reflection of Paxton's experience with greenhouses, but more than this it was a daring adventure in the use of carefully designed factory-fabricated components and of precision rather than sheer mass to achieve structural strength.

[3] *Loc. cit.*

[4] *Loc. cit.*

[5] Harrison et al., *op. cit.*, p. 3.

[6] Sigfried Giedion, *Space, Time and Architecture* (Cambridge: Harvard University Press, 1941), pp. 124–7.

[7] *Ibid.*, pp. 129–34.

[8] Giedion, *op. cit.*, p. 186.

[9] Tallis's *History and Description of the Crystal Palace*, ed. by J. G. Strutt, in 3 vols. (London: The London Printing and Publishing Co. [c. 1851]), Vol. I, p. 11.

C. Impetus of the Gold Rush

These, however, were but sporadic beginnings. The first real impetus to the production of prefabricated houses appears to have been the Gold Rush of 1848.[10] Houses were exported to California from our eastern seaboard, from England, France, Germany, Belgium —even from China, New Zealand, and Tasmania. In the New York area alone some 5,000 houses for shipment to California had been contracted for or produced by 1850. Models which cost $400 in the East sold for $5,000 on the West Coast. And from Manchester, England, came several hundred houses of corrugated galvanized iron, some of them outfitted with wallpaper, carpets, furniture, and water closets. But the end of this boom—which was the first of several which were to push prefabrication for one reason or another—came in 1850, when the building materials market in California was flooded and prices fell sharply. After a local lumber industry had developed in response to the huge demand, the high shipping cost quickly put the imported prefabricated house out of the picture.

D. Prefabricated Camp Buildings

New settlements provided one market for early prefabricators; the demand for various types of camp buildings and cottages provided another. The continuing commercial development of panelized wood houses for this market dates from at least as far back as 1861. In that year Skillings and Flint, lumber dealers of Boston and New York, patented a system of building houses from a few standardized panels and a number of other interchangeable parts (see Figure 1). Their impressively bound, gilt-edged catalogue claimed that their houses could be erected in three hours and showed a number of designs suited to plantation and army camps. Indeed, this firm sold a good many houses to the Union Army.[11] In Germany the firm of Christoph & Unmack, organized in 1882, was soon to begin production of timber houses constructed of load-bearing panels. Its products were chiefly huts, cabins, and labor camps and were ultimately to be shipped in

[10] A very interesting account of this boom in prefabrication is given by Peterson, *op. cit.*, pp. 42–6.

[11] Peterson, *op. cit.*, p. 46.

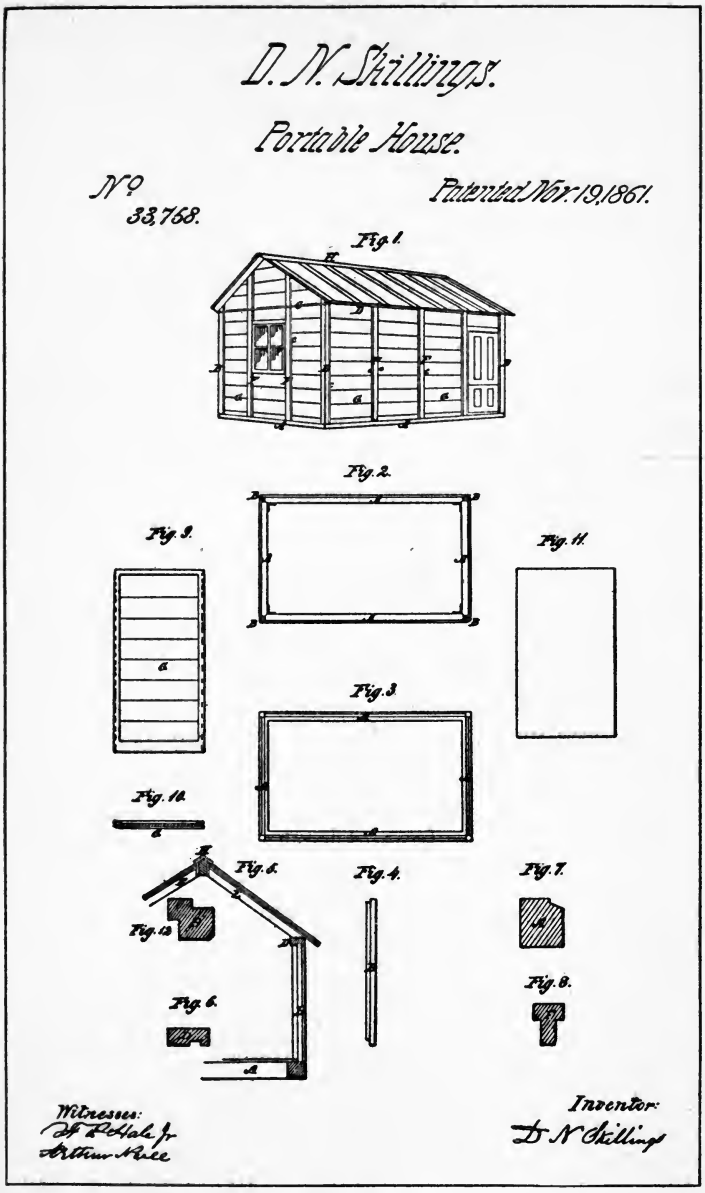

Figure 1. Skillings Patent Drawings

very large quantities to many parts of the globe.[12] A decade later, in 1892, Ernest F. Hodgson founded his company in Boston and began the manufacture of panelized dwellings of wood (see Figure 6). This firm, which is the oldest known to be still in the industry today,[13] started by making small structures such as chicken houses, children's play houses, and dog houses. It received a boost when, with the advent of the horseless carriage, the demand for "auto stables" arose. A further effect of the automobile was to increase the demand for vacation cottages, enabling the company to enlarge its operations and furnishing a major part of its business until this day. This enterprise has been a notable instance of successful commercial development on a conservative basis. The house remained of essentially conventional wood frame construction, modified to permit shop fabrication in panels. There was no rush to get into large-scale production nor any attempt to provide a universal set of building components adaptable to any plan. Emphasis was placed on modest single-story houses, and sales were direct to the customer, featuring speedy erection and good quality rather than low cost.

II. 1900–1920: Developments in Precut and Concrete Construction

A. The Precut House

Shortly after 1900 a peripheral development of prefabrication became commercially important. This was the precut house, sometimes referred to as the "mail-order" house, and in some respects the first of the "self-help" houses designed for owner erection (see Figure 7). The first decade of the century saw the entrance into this field of a number of firms which were to become prominent in it: The Aladdin Co., Bay City, Mich.; Gordon-Van Tine Company, Davenport, Ia.; Pacific Systems Homes, Inc., Los Angeles, Calif.; Sears,

[12] Harrison et al., *op. cit.*, case sheet on Christoph & Unmack.

[13] The E. F. Hodgson Co. was combined with Allied Housing Associates, Inc., in 1944 to form the Allied-Hodgson Housing Corp. Each of the original companies does business as a division of the corporation.

Roebuck and Co., Newark, N. J. Although the mere precutting, notching, and marking of the lumber to be used in a wood frame dwelling might not appear to deserve the name "prefabrication," the precut house warrants consideration here for several reasons. One is that the grading, cutting, marking, and packaging of lumber and the preassembly of windows and doors in the precutter's plant have usually been carried out on an efficient line production basis. Secondly, the precut house has generally involved a number of standardized products in a field that long resisted standardization. Thirdly, it has made possible the large-scale estimating, purchasing, and collecting of materials (including roofing, shingles, hardware, etc.) to form a house package and has established the fixed price character of this package. Lastly, precutting was, until World War II, probably the most widely used application of factory production to housing; "certainly a quarter of a million houses have been built according to this method—a number probably in excess of the total number of sectional and prefabricated houses built to date (1943), including the wartime demountables." [14]

B. Early American Experimentation

It was also about the turn of the century that early experimentation began in America; it was concerned primarily with concrete as a material, and here we may mention Grosvenor Atterbury as a pioneer. His research in the techniques of housebuilding began in 1902, first at his own expense, subsequently with philanthropic support (after 1907 chiefly from the Russell Sage Foundation). He has continued until the present day his search for better methods of construction with cast cementitious materials. About 1907 Atterbury developed a system of large [15] precast hollow-core panels for walls, floors, and roofs. Between 1910 and 1918 several hundred houses based on this system were built for the Russell Sage Foundation in Forest Hills, Long Island, the units being transported to the site in trucks and erected there with derricks. This was a significant experiment in a new construction technique, yet the importance of Atterbury's work lies not so much in the achievement at Forest Hills, which, though of high quality, was not of radically low cost, but rather in his approach

[14] Bruce and Sandbank, *op. cit.*, p. 57.

[15] Wall panels, for instance, were of story height and 6′ 0″ to 8′ 0″ wide.

and in the persistence which marked his attempt to develop some sort of casting process, a method for which he saw great promise in building. His system—along with others involving large precast concrete units—entailed difficulties in the transportation and handling of heavy units and in the large investment in molds which was required because of the lengthy curing period for each casting. Therefore, although a large-scale project such as that at Forest Hills might overcome these difficulties economically, it was evident that the system was not well suited to the erection of isolated free-standing houses or small developments. To solve these difficulties, Atterbury has since experimented with various other cementitious materials and has developed better molds and worked out methods of shortening the curing time.

Another development in which Atterbury pioneered was the growth of interest in prefabrication as a means of providing shelter for the vast bulk of our housing needs, not for just a few exceptional ones. Before the early twentieth century, the prefabricated dwelling had been of importance for new settlements, camp cabins, and vacation cottages—uses in which a decrease in site work was desired even, if necessary, at an increase in total cost. But as the ever-accelerating industrialization of our life proceeded along with a great surge of urbanization, and as our attitudes towards slums and blight changed,[16] it was felt that house production methods were falling far behind industrial techniques in other fields, and prefabrication came to be regarded as a means of providing more economic shelter for the mass of our housing requirements. There was no overnight change, of course, nor can the turning point be placed with too much certainty in the first decade of the century.[17] Yet it seems reasonably clear that after this time the interest in prefabrication was connected less and less with a few special housing markets and more and more with low cost in the general housing market; it was increasingly an interest in the overall industrialization of house production as an answer to what was gradually to become known as "the housing problem."

[16] Evidenced by the passage, between 1870 and 1890, of many municipal ordinances governing the health and safety standards of housing.

[17] Atterbury's work is, however, the earliest example our research has disclosed of philanthropically supported experimentation in prefabrication; the results, including patents, were offered to any "non-profit institution willing to continue the work along proper lines looking towards a scientific solution of the housing problem." (Quoted from a statement by Atterbury submitted to A. F. Bemis in 1935, files of the Bemis Foundation.)

C. The Emphasis on Concrete

The work of Atterbury was by no means the only experimentation with novel housebuilding methods during the first two decades of the century.[18] Many of the other attempts also employed concrete and generally involved but little prefabrication; they were limited to the precasting of wall units or the use of factory-produced forms. In 1908 Thomas Edison proposed a method of casting two- and three-story houses in one operation. Sectional cast-iron forms were to be bolted together at the site, and concrete, carried by a conveyer, was to be poured into a funnel at the top of the enclosure. Edison's idea attracted a good deal of attention but was soon abandoned as impractical. Yet it is interesting to note that the monolithic concrete house is still a subject of considerable interest and is today being carried out in single-story dwellings with equipment at least as complex as Edison proposed.[19] Other ideas were to follow: the Merrill System of monolithic concrete walls formed *in situ* (1908); Simpson Craft, a complete house system of concrete, about 90% precast (1917); Lakeolith, the precast ribbed panel system of Simon Lake, the submarine designer (1918); the Hahn Concrete Lumber System of precast and site-formed concrete (1919).[20] Some hundreds, perhaps a few thousand, houses have been produced by these and similar concrete constructions, but no one system has ever been adopted on a mass-production basis. The early experimental work in concrete did not develop any fully realized techniques; it was rather a sign—perhaps the first sign—of the growing interest in the invention of prefabrication systems; it was in a sense the forerunner of what we call the prefabrication movement.[21]

[18] Bemis and Burchard, *op. cit.*, p. 617, list nine other examples.

[19] For example, R. G. LeTourneau Inc.'s Tournalayer and Ibec Housing Corporation's house-sized form.

[20] For further information on these and other systems see *Report on Survey of Concrete House Construction Systems,* Portland Cement Association (Chicago, 1934); also works cited in footnote, p. 7.

[21] Bruce and Sandbank, *op. cit.,* pp. 30–40.

III. 1920–1930: Experimentation with Prefabrication

A. The Postwar Stimulus Abroad

We have passed over the World War I period because, unlike the recent war years, it was not very important to prefabrication. The production of precut and to some extent of panelized wood buildings was stimulated, but prefabrication as an industrial development was not appreciably promoted or advanced. The postwar years, however, did bring a strong stimulus to prefabrication, chiefly in Europe. While America continued to experiment with prefabrication, Europe, by contrast, built with it, and we might digress for a moment to consider what was accomplished there and why.

1. Great Britain

The earliest developments were in Great Britain, where the housing shortage, the dearth of bricks and of bricklayers and other craftsmen, and the surplus of steel capacity all combined to provide a strong economic motivation for trying new methods of building. Most of the British preferred brick, but alternative constructions had to be available in case of trouble, so that the government could perform on its promise of "homes for heroes."

By 1920, the Ministry of Works had approved some 110 systems of construction, of which, excluding systems of concrete masonry, perhaps 12 involved some degree of prefabrication, though not even all these reached the production stage.[22] There were no standards of functional performance employed, nor were the systems approved necessarily cheap or easy to erect. Rather, the emphasis was on meeting the situation described above, and so, between the years 1918 and 1925, a large number of partially prefabricated houses were built of elements such as sheet steel, rolled steel frames, concrete masonry, story-height precast concrete units, and expanded metal sprayed with cement. The last type of construction, combined with

[22] Harrison et al., *op. cit.*, p. 5.

a steel frame, formed the basis of the Dorlonco house, some 10,000 of which were built in England between 1920 and 1928.[23] Many later proved defective in that, because of insufficient cover, the metal lath rusted and the cement rendering cracked and fell off. In the years following 1918 some 10,000 concrete houses were erected by four big industrial concerns using either precast pier and panel construction or precast slabs to enclose a site-poured frame, and from 1926 to 1928 another big corporation, G. and J. Weir, Ltd., built 3,000 houses, using timber frame, steel plates, and fiberboard—materials relatively rare in British housing. It is important to note that until World War II, with the exception of the precut and possibly certain panelized, but otherwise conventional, wood frame houses, no American prefabrication system was produced as extensively as the Weir and Dorlonco houses.

Yet even with such extensive trials, all these prefabrication systems fell into general disuse between 1926 and 1930. For one thing, there was labor trouble in connection with the Weir houses because of the fact that engineering union labor was used at lower wage rates than unskilled building-trades labor; as a result the building trades refused to work for any local authority which erected Weir houses. But, more than this, it is important to understand that the prefabricated houses were considered as makeshifts and, at least in part, as pawns in the struggle with conventional building labor. When the shortage was overcome and the normal building methods could handle the demand, few prefabricated houses were built. They had not proved cheaper than the brick houses in whose stead they were being built, and they could not compete on even terms because of the prejudice against them as being new, untried, and substitute products.

> . . . the new types were, in design, mostly inferior imitations of brick buildings. No attempt had been made to evolve designs which suited, and took advantage of, the new structural concepts. So utterly bankrupt was the movement in this respect that the new constructions were laboriously worked to the same niggling plans which were in common use for brick houses at the same time. It was not realized, and it is still not realized, that plans and designs suitable for brick buildings, which can be cut and chopped about in extraordinary detail, are totally unsuited to the factory-made articles of standardized size which require the clearest and simplest planning for their economical use.[24]

This statement might well form the epilogue to a number of other essays in prefabrication.

[23] *Ibid.*, case sheet on Dorlonco.

[24] D. Dex Harrison, "An Outline of Prefabrication," in *Tomorrow's Houses*, ed. by John Madge (London: Pilot Press, 1946), pp. 118–9.

2. Germany

The Germans, because of the economic consequences of the war, did not begin to experiment with prefabrication on a large scale until about 1926, by which time the British were already returning to conventional building methods. As in Britain, however, the necessity of providing housing under abnormal conditions brought into effect many new approaches. A large experimental program, exceeding in scale anything attempted previously in any country, was carried out under the direction of the State Research Institute (Reichsforschungsgesellschaft), a government department charged, among other duties, with organizing and controlling building throughout Germany. Many new schemes for low-cost housing construction were tried, and the costs and physical results compared. A big slump in the steel trade in 1927 left Vereinigte Stahlwerke, the German steel trust, with considerable excess capacity and the desire to seek new outlets. As a consequence, this trust introduced a number of different steel systems of three principal types: close-spaced frame, open-spaced frame, and load-bearing panels. The Germans did not build as many steel houses as the British, but they evolved more systems. Their development of concrete construction involved the introduction of various aggregates such as clinker, foamed slag, and pumice, which were often precast into large story-height wall panels to be hoisted by crane into place within a structural steel framework. The way in which concrete and steel were used was largely influenced by the fact that much of the housing built was in the form of apartment houses going to three or more stories, and thus prefabrication was put on a much wider basis than in Britain, where it was restricted largely to single-family houses, or in America, where the concentration was on single-story, single-family houses. British writers conclude that "when prefabrication is thus applied to large buildings it escapes the stigma of cheapness and nastiness and the development is of much more fundamental importance, invading as it does the whole fabric of the building trade." [25] It should also be mentioned that by 1929 Hugo Stinnes and Hugo Junkers, two major German industrialists, were considering industrial methods for improving housing production. Junkers, the expert in aeronautics, was making elaborate experiments in airplane-like stressed skin construction.

Unfortunately the fine pioneer work of the Germans with metals and concrete, much of which was leading to substantial cost reduc-

[25] Harrison et al., *op. cit.*, p. 8.

tions, was curtailed by the depression in 1932 and completely halted when the Nazis came to power in 1933. The use of steel for house-building was prohibited, and all civil building was limited by the channeling of resources to the construction of fortifications and military and party buildings. In addition, the rational approach to building was condemned, and it was decreed that "Germanic" ideals were to be reflected in new construction.

3. France

The French, faced, like the British, with a well-rooted conventional architecture, appear to have begun their prefabrication efforts relatively late. Their structural engineers were making great advances, but in such other directions as the development of reinforced concrete. In the year 1927, however, the steel industry started to sponsor systems which used steel for interior and exterior wall surfaces. Some of the units were similar to those introduced in America in the early thirties, and there were also steel frame structures and structures of stucco on metal lath, the last being developed with more success than marked the British projects of the same type. A development related to prefabrication was the move to standardize and coordinate the dimensions of various building elements, which received an early start in France, for beginning in 1929 the Ministry of Commerce promoted a campaign towards this end. This was of importance to prefabrication in its broadest sense because it was pointed towards the elimination of cutting and fitting at the site and a consequent relative shift of work to the factory. Several architectural competitions in the thirties, out of which emerged a number of proposed prefabrication systems, revealed that the ideas of standardization and modular design[26] were gaining acceptance to a substantial degree.[27]

[26] See below, p. 24.

[27] Probably the most widely known of the French prefabrication efforts was the system of the engineer Eugene Mopin, used in the construction of multistory apartments in several large projects in and about 1934. The Mopin system, a combination of prefabrication and site fabrication, consisted of a light steel frame encased in concrete with intermediate posts of precast reinforced concrete and external walls of precast vibrated concrete slabs keyed into the posts. Though the buildings have been criticized for poor sound- and thermal-insulation qualities, they were perhaps the most significant experiment of the decade in precast construction.

4. Sweden

Meanwhile, in Sweden designers made use of local materials to meet their problems. In contrast to Britain and France, Sweden had an abundance of timber and prefabrication systems were evolved in terms of this material and, in the early years, a not very economical use of it. By 1923 technicians had introduced prefabricated houses of wood to meet the extensive housing shortage which developed after World War I. A major interest in the Swedish prefabrication experience lies in the role of the municipal government of Stockholm which, through its planning of land use, its provision of credit, and its self-help plan, encouraged the use of prefabrication for the housing of families of low and moderate incomes. The most interesting feature of this program was that the occupying family itself often supplied the unskilled labor needed in the building process. The city provided plans and skilled labor, such as carpenters, plumbers, and electricians, for a reasonable fee and furnished guidance to the family, who made the excavation, laid up the cement-block basement walls, helped the skilled craftsmen erect the shell and install the utilities, and carried out much of the final finishing work.

The prefabrication systems were all similar in their main characteristics: wood framed, load-bearing panels surfaced externally and internally with vertical tongue and groove boards and filled with an insulating material such as sawdust. This was hardly a pattern suited to lands where wood is a relatively scarce or costly material (and this includes even the United States). The panels were delivered complete with doors and windows, were the full height of the house, and came in various widths to suit a number of designs. They were in general extremely heavy. Standards were high, and maintenance has since proved economical. Involving as it did municipal ownership of land, municipal home financing, and municipal provision of many building services, this program represented the most comprehensive public assistance to prefabrication to that date.

The self-help scheme was successful enough to persuade private contractors to offer the same service to homebuilders who were planning to live on either privately or municipally owned land; "in fact, the majority of small houses built in the garden suburbs on the 'self-help' plan have been constructed by private builders. But having pioneered in this method, the city continues its program, constructing on an average of three hundred dwellings a year." [28]

[28] John Graham, Jr., *Housing in Scandinavia* (Chapel Hill: University of North Carolina Press, 1940), p. 67.

More than 3,000 self-help houses were built under the municipal plan alone between 1927 and 1940.[29]

B. Experimentation and Small-Scale Development in America

Returning to a consideration of what was happening in America during the twenties, we note at once the difference in the role of government as compared with Europe. Whereas abroad there were various types of public stimulus to prefabrication—public housing, government-supported research and development, government encouragement of modular design—here there was, except for a small simplification and standardization program of the U. S. Bureau of Standards, no federal interest in prefabrication as such, or in related developments. We were in the midst of prosperity and a record-making building boom. Neither the government nor any of the big corporations associated with the building industry had reason to push prefabrication, and consequently development in this field was carried on by a handful of crusading individuals and small companies with limited financial resources.

1. Work in Concrete

In the first part of the decade the interest was primarily in the application of concrete to small-house construction both by on-site methods—which really involved little or no prefabrication—and by use of precast elements (see Figure 2). Instances of the latter type were several systems of story-height units of precast reinforced concrete: Armostone (1920), Moore Unit (1920), and Tee-Stone (1923). Only the last of these systems involved more than the walls of the dwelling; floors, ceilings, and roofs were handled in a conventional manner, and, as was the case with almost all the early proposals, no attention was devoted to the mechanical equipment of the house. It is probable that a total of not more than 500 houses was built by means of these systems. Meanwhile Grosvenor Atterbury was continuing his work, which from 1919 to 1921 was being carried out in a laboratory supported by the American Car and Foundry Co. The conclusion

[29] *Ibid.*, p. 59.

reached here was that while a casting process was a sound solution to the problem, further development by a non-profit agency was necessary before a commercial enterprise could be successfully undertaken.

It should be noted that while these and subsequent developments in the use of large precast units were proceeding, the role of concrete in low-cost single-family dwellings increased significantly through the use of $16'' \times 8'' \times 8''$ concrete blocks. Such blocks, involving but slightly more prefabrication than bricks, have, through the years, been accepted to the point where they form the basis of more than one-tenth of our annual housing production.[30]

2. Research by Bemis

It was early in the decade (1921) that Albert Farwell Bemis, a Boston industrialist, began the sponsorship of research in prefabrication. Through Bemis Industries, Inc., Mr. Bemis owned and controlled a number of concerns manufacturing building materials and products. Among these, the Housing Company was equipped to fabricate and erect houses and other buildings by either conventional or novel means, while Bemis Industries itself maintained a laboratory and staff devoted to research in housing. For the next 10 years, a period during which prefabrication was quite removed from the limelight, Bemis Industries, Inc., studied building materials and structural methods in its laboratories and in the field, experimenting with a large number of different types of construction.[31] Its research program comprised three stages: development of a scheme on paper; laboratory construction and testing of a full-size section; and finally, if justified, the building of a house to test the new method for physical performance and cost. Although the program proceeded by fundamentally logical considerations from one scheme to the next, it is perhaps fair to remark that the successive attempts were too little related to one another. The lack of continuity in approach may be noted when we consider that the 22 systems which were tried included such elements as solid wood panels, plywood panels, concrete poured *in situ*, precast gypsum blocks, precast gypsum slabs, gypsum tubes, an excelsior-magnesite material known as "Acoustex," steel

[30] Bruce and Sandbank, *op. cit.*, p. 40.

[31] For a summary of this work, see John Burchard II, "Research Findings of Bemis Industries, Inc.," *Architectural Record*, 75 (January 1934), 3–8.

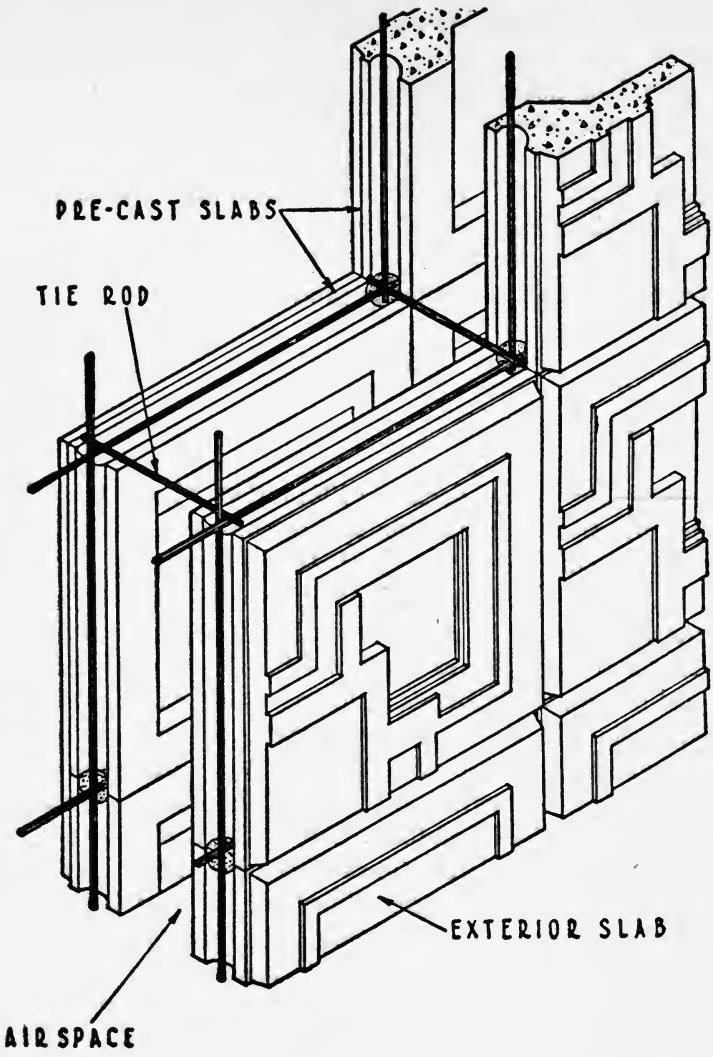

Figure 2. Precast Concrete Systems of the 1920's: (1) Frank Lloyd Wright

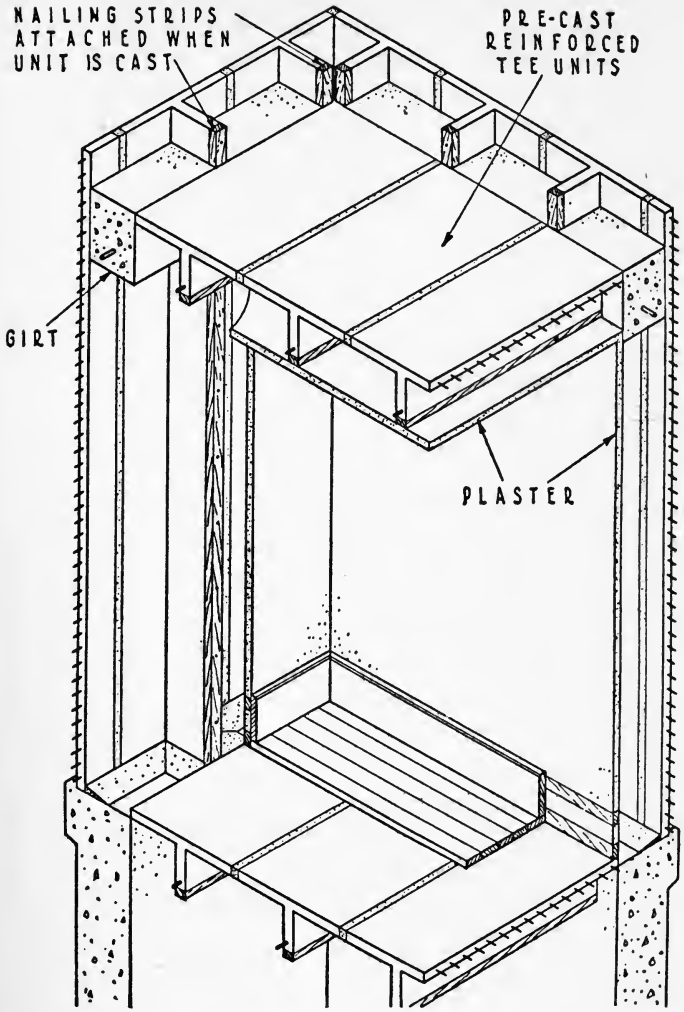

Figure 2. Precast Concrete Systems of the 1920's:
(2) Tee-stone

frames, and steel panels—a pretty fair sampling of all the then-known construction materials. During the twenties, so far as we know, Bemis Industries, Inc., spent more time, money, and effort on this type of research than any other single organization. With the advent of the depression, however, it was forced to curtail its activities somewhat, and from 1931 until Bemis' death in 1936 effort was concentrated on developing new materials in the laboratory (particularly a material which would at once provide structural strength, insulation, and surface finish) and on the development of his cubical modular method of design. If none of the systems developed by Bemis Industries, Inc., was ever exploited commercially on a large scale, it is nonetheless true that its contribution was a significant one, for the development work on materials and structural methods, particularly on joints, provided a good deal of practical material for those who were engaged in technical problems.

Mr. Bemis' cubical modular method of design evolved from his work towards better and more flexible coordination of structural components. He concluded early in his researches that a fundamental, all-inclusive basis must be established which would coordinate the dimensions of all structural components, building materials, and installed equipment. The cubical modular method was developed as a theory of design, but simultaneously its practicability was proved by applying it to a variety of materials and constructions in experimental houses which were built and sold. This objective explains some of the discontinuity in construction ideas referred to in the previous paragraph.

A theoretical discussion of the cubical modular method is given in *The Evolving House,*[32] Vol. III, *Rational Design.* The method requires that the space occupied by the building be considered as a continuum of cubes formed by parallel lines in each of the three dimensions, and spaced on a standard module for building layout and assembly details. Mr. Bemis showed that, in order to permit a maximum of freedom, the basic module should have a length of the order of magnitude of a wall thickness, and he chose 4″ as the unit most consistent with existing products and practices (as, for example, the 16″ spacing of studs in wood frame walls). He further demonstrated that the 4″ module could provide the basis for a sound standardization of all dimensioned building products with at least as great flexibility of building layout as was available with former "stock" sizes.

[32] Albert Farwell Bemis and John Burchard, 2nd, *The Evolving House:* Vol. I, *A History of the Home;* Vol. II, *The Economics of Shelter;* Vol. III. *Rational Design* (Cambridge: The Technology Press, 1933; 1934; 1936).

The first large commercial application of the method was made in 1937 by Homasote Co. with technical assistance from Bemis Industries, Inc. The modular details developed for its Precision-Built construction enabled Homasote to produce any house designed on the 4″ modular basis by relatively simple jig cutting and assembly methods.

In 1938 the heirs of Mr. Bemis founded Modular Service Association as a non-profit corporation to help the building industry in developing dimensional coordination. The industry effort was organized under the voluntary committee procedure of the American Standards Association and is known as ASA Project A62, with the American Institute of Architects and The Producers' Council, Inc., as joint sponsors. Through Project A62 the industry has adopted the cubical modular method as the American Standard Basis for Dimensional Coordination, with appropriate changes in terminology. The method is called "modular coordination," and the "modular lines used as a design matrix" have become the "standard grid to which building plans and assembly details are referenced." The standard module is 4″. The objectives of modular coordination are discussed on p. 81.

Through his work on modular design Bemis gave impetus to a much-needed movement in building, one which was to serve prefabrication through the elimination of much cutting and fitting at the site and which was to find added support from architects, building materials manufacturers, and the government as time went on. Last, but not least, was his contribution in *The Evolving House,* an exhaustive study which, in treating modular design and prefabrication seriously for perhaps the first time, gave these ideas real form and stature.

3. Early Steel Systems

During the latter part of the decade several steel frame systems were introduced, but these were not of great significance. Those sponsored by the McClintic-Marshall Corporation and the Gary Structural Steel Corp., for instance, entailed prefabrication only of the framing members and used these with the close spacing typical of a wood frame structure. Consequently, little if any economy was achieved; instead the emphasis of the proponents of such systems was on the superiority of steel over wood from the points of view of strength, fire resistance, and dimensional stability. Furthermore, since the interest of the sponsor did not usually extend beyond the

frame, there was the problem of overcoming the inertia of builders and of persuading them to depart from established practice for only a part of the structure, especially when the use of collateral materials may have offered some problems. The steel framed house of more recent design tended to use this material economically, taking advantage of its various properties and more efficiently integrating the frame with the rest of the structure.

4. The Radical Approach

One of the most interesting designs of the period was Buckminster Fuller's Dymaxion house (1927) (see Figure 8)—interesting not so much because of the details of the house itself, which in its original form never progressed beyond the model stage, as because of the approach to the problem. Fuller serves as the symbol of a group of men who have thought of prefabrication in quite basic terms and have emerged with the conclusion that the design of the house must be fundamentally altered if we are adequately to meet the housing problems of our civilization—that, in certain respects at least, revolution rather than evolution is necessary. Such a group should include, among others, those who have speculated about houses suspended from a central mast: the Bowman brothers, George Fred Keck, Eero Saarinen, Richard Neutra, Peter Pfisterer, and, of course, Fuller himself; about externally suspended houses: Paul Nelson, Keck, and Leland Atwood; about hemispherical houses of monocoque construction: Martin Wagner and Wallace Neff; about various types of mobility in housing—the trailer house, the folding house, the sectional house: Corwin Willson, William B. Stout, Temple H. Buell, Carroll A. Towne, Carl Koch, and John Bemis. This is not a complete list, nor were all these designers thinking in terms of low-cost housing or the industrialized production of housing, although most of their schemes did involve a good deal of prefabrication. The kinship they bear to Fuller is in their attitude towards design, and it is this attitude that is the important thing about the Dymaxion house, not that it was to be suspended by wires from a central mast, or that it was to be hexagonal in plan, or that it was to be air conditioned, have an automatic laundry, and a self-contained waste-disposal unit. Indeed, it was as an *attitude* that Fuller himself later characterized the house:

> An attitude to think truthfully. To think truthfully in the terms of the latest achievements of the intellect, quite unfettered by history's relatively

temporary national, political and aesthetic bonds. Such bonds are not habits of thinking but habits of not thinking.[33]

Looking back,[34] Fuller has explained that behind the design of Dymaxion I lay an effort to maximize the performance of the house per pound of material in its structure. This objective led to a search for the means of enclosing the maximum volume with the minimum surface, for ways to use light materials, and for a structure which would utilize metals in tension rather than compression in order to take greatest advantage of their strength properties. Some have held that Fuller was not as rational as he supposed. Lewis Mumford pointed out, for instance, that "though Mr. Fuller . . . believes that he has swept aside all traditional tags in dealing with the house, and has faced its design with inexorable rigor, he has kept, with charming unconsciousness, the most traditional and sentimental tag of all, namely, the free-standing individual house. If we are thorough enough in our thinking to throw that prejudice aside, too, we may, I suspect, still find a place for the architect in modern civilization." [35] Another aspect of Fuller's thinking that has been questioned is his pronouncement of performance per pound as a figure of merit for house design. Why, it has been asked, *per pound of house?* What if it should cost more to produce and use the light metals Fuller calls for than to fabricate and transport somewhat heavier materials? How important is transportation cost in the final cost, and to what extent does transportation cost depend upon bulk rather than weight? Perhaps the reason that the designers of houses have not thought in terms of performance per pound is that they are not so deeply concerned with gravity as are aircraft and ship designers. But this is not the place to examine the validity of details of Fuller's argument. The important thing is that he should have thought in terms of *some* figure of merit and in terms of what technology had provided and could provide in materials and structural methods.

At the time his house was introduced, Fuller writes,[36] he extrapolated curves of industrial progress, of housing demand and supply, of invention gestation, of the range and frequency of per capita travel, and concluded that the house, with all the improvements in technology that would take place in the meantime, could not be industrially

[33] Buckminster Fuller, "Dymaxion Houses: an Attitude," *Architectural Record,* 75 (January 1934), 10.

[34] R. Buckminster Fuller, *Designing a New Industry: A Composite of a Series of Talks* (Wichita, Kan.: Fuller Research Institute, 1946).

[35] Lewis Mumford, *City Development: Studies in Renewal and Disintegration* (New York: Harcourt, Brace & Co., 1945), p. 73.

[36] Fuller, *Designing a New Industry,* p. 24.

produced for some 21 or 22 years, until 1948–1949. For a while, in the last few years, it looked as though Fuller's prognostication might have been startlingly accurate. A new version of the Dymaxion house was prominent in the news. Basically the same as the 1927 design, it had been made round instead of hexagonal and had been lowered on its mast and fitted with a ventilator on top; recent developments in light metals, in synthetics, and in aircraft production techniques were to be applied to its manufacture; it was even accorded a "better than even chance of upsetting building industry." [37] But this later Fuller house never got into production, and changes introduced after Fuller left the company did not help the situation.

It is clear that in 1927, even if the technology had been capable of it, no one was in a hurry to produce anything so revolutionary. The building industry had just finished one of the biggest years in its history and had already passed the turning point of its boom. There was little talk of a housing shortage; in fact it seemed to industry that plenty of houses, if not too many, were being produced, even if they were not going to those who needed them most. Although the ideas of Fuller and other members of this group of radical thinkers were not realized in production, they still served two ends: they caused the architects and engineers to think more deeply about house design, and, perhaps not so happily, they caused considerable public excitement. The outburst of inventions and publicity really arrived, however, with the thirties, when the nation, struggling through a depression, turned anxious eyes towards the technical world in the hope that some mass-production miracle might occur.

IV. 1930–1940: Prefabrication Attains the Status of a Movement

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A. The Background Influences

It was in the early thirties that prefabrication became a widely recognized movement, and interest in one aspect or another of the

[37] "Fuller's House," *Fortune,* XXXIII (April 1946), 167. But see also: "What became of the Fuller house," *Fortune,* XXXVII (May 1948), 168.

idea spread to a much wider group than the handful of inventors and small companies which had previously been concerned. The spread of this idea may be attributed to a confluence of factors, economic, social, and technical.

1. Economic Factors

There was, first of all, the overwhelming effect of the depression, the impact of which stimulated the search for new kinds of employment and investment opportunity. Though builders and mortgage institutions were not yet concerned about a housing shortage, it was clear to many who were casting about for new markets that a radically low-cost house would offer just such an opportunity. It was generally recognized that the purchase of a new house was beyond the means of at least half of the families in America.[38] Here was a market if only one could provide the product. But not only was there a search for new investment opportunities; it was also necessary to find an outlet for the potential output of existing investments in plant and equipment. The steel industry, for instance, operating at one-quarter of capacity,[39] looked desperately for a new market to absorb what it was capable of producing. Similarly, some of the large building materials producers sought to get housebuilding, which had slumped to 10% of its 1925 peak,[40] out of the doldrums. The consequence was a widespread development of themes similar to that of an article in *Collier's* entitled, "We Can Build Our Way Out," [41] which called for a new house manufacturing industry to end the depression.

[38] In the mid-thirties, when a mass of statistical investigation began to provide us with some disturbing facts about our economy, it turned out that, if one took the crude rule of thumb that a home buyer's income should equal half the cost of his house, some 79% of American families could not afford a "low-cost" house priced with lot at $4,000 (*Family Expenditures in the United States,* National Resources Planning Board [Washington, 1941], Table 1, p. 1).

[39] *1936 Supplement, Survey of Current Business,* U. S. Department of Commerce, p. 118. In 1932 ingot production was at 20% of capacity; sheet steel production at 25% of capacity.

[40] Total non-farm dwelling units started in 1925: 937,000; in 1933: 93,000 (*Housing Statistics Handbook,* Housing and Home Finance Agency [Washington, 1948], p. 2).

[41] *Collier's,* 91 (June 10, 1933), 12 ff.

2. Social Factors

Added to this general economic outlook was a social atmosphere in which there were, on the one hand, those whose faith in our economic system had been considerably shaken and who argued that at least in housing the government must take an active role in providing for the lower-income groups, and, on the other, those who were convinced of the basic soundness of a private enterprise economy. The industrialization of housing was a challenge to those who believed in the private industrial system and thought it could be made to work in all areas for the benefit of all the people. There were other relevant social trends: the increasing concern about economic insecurity, the movement of employment opportunities, and the mobility of the population; the increasing scope of government activities; the growth of a housing movement. These will be discussed more fully later.

3. Technical Factors

There were also technical developments during this period which deserve brief mention here: the progress in plywood manufacture brought about by improvements in glues and veneer cutting; the better utilization of wood seconds and wood waste to make plastics, wallboards, and hardboards; the expanded production of other sheet materials made from gypsum, asbestos, cane fiber, newspaper, etc.; the development of sheet steel and the continuous strip and cold-rolled processes; the improvement in alloys, especially of the light metals; and the treatment of cementitious materials by vibrating, aerating, and use of lightweight aggregates. Again, these will be discussed later.

This complex of economic, social, and technical factors will be analyzed here by summarizing the activities of those groups which concerned themselves with broad applications: the non-commercial research organizations, the government, and the business and financial world.

B. Non-Commercial Research and Development

One aspect that distinguished American research and development in prefabrication from those in other countries was their continuity.[42] In America, as elsewhere, commercial sponsors were active, in general, only if they saw profit possibilities. But here, unlike most other countries, there was a core of constant activity in research which was carried on with the principal object of providing better and more economic shelter. True, the scale on which development and experimentation were carried out varied with business conditions, but at least a small amount of effort was consistently expended regardless of the immediate economic problems at hand.

1. Pierce Foundation

In the twenties there were Bemis and Atterbury, and now, in the thirties, other organizations entered the field. The Housing Research Division of the Pierce Foundation,[43] in Raritan, N. J., was founded in 1931 and under the direction of Robert L. Davison began a search for materials and structures that would yield a house of lowest possible cost consistent with adequate physical standards. Among the materials which this group tried were concrete, plywood, composition board, cellular glass, stabilized earth, and a hydro-calcium silicate composition known as "Microporite." Behind much of its experimentation lay the same aim that motivated Bemis: to find a single material which would serve both as structure and as enclosure. A number of test houses were erected. The first, in 1932, had an open-spaced (12½′) steel frame and floor-carrying walls of welded lattice trusses encased in a cementitious material, a system intended primarily for multistory apartment construction. A second experimental house (1935) also used an open-spaced steel frame with precast reinforced Microporite slabs for walls, floors, roof, and partitions. Both these structures used panels horizontally, a type of design which the Foundation tended to favor for its flexibility in planning and fenestration, de-

[42] Harrison, *op. cit.*, p. 124.

[43] The John B. Pierce Foundation of New York City was chartered in 1924 to carry on educational, technical, and scientific work in the general fields of heating, ventilating, and sanitation. It was endowed in the will of John B. Pierce, New England industrialist and financier.

spite the much more common preference for vertical elements. Later a community of 20 plywood houses in Highbridge, N. J., was built to permit a continuous study of family needs and maintenance problems.

The Foundation has also done considerable work on plumbing and heating equipment and was largely responsible for the integrated mechanical core as it first reached the market in 1935 in the American Motohome. Its work was reflected commercially in at least two other ways. The studies of floor plans and family living habits were at least partially responsible for the $24' \times 28'$ single-story house which has to a large extent become "standard" in the low-cost field. A second instance was the Cemesto House, released for commercial development with considerable success in war housing.[44] This dwelling had an open-spaced wood frame clothed with horizontally laid slabs of Cemesto, a sandwich material composed of a cane fiber insulating core faced on both sides with cement asbestos sheets. At the present time the Foundation is continuing its work on a number of phases of house construction, concerned particularly with systems of prefabrication employing stressed skin plywood panels in connection with structural frames of either light-gauge steel or wood.

2. Universities

Purdue University's Housing Research Project, instituted in 1935, was another non-commercial agency that carried on work in the field, much of which was done in cooperation with industry. One of its early efforts was the building and testing of five commercial types of low-cost house, two of which were prefabricated. Engineering and cost studies were made and published. Considerable work has also been done in the fields of heating and ventilation.

Other universities were, of course, also conducting research in related areas, yet this work was generally not focused specifically on the problem of building the house shell, but was more often concerned with various types of economic studies, with family needs, or with mechanical equipment. This was in part a reflection of the peculiar organization of the housebuilding industry which left it, by comparison with other industries in, for instance, the chemical and electrical

[44] For instance, the community built for the employees of the Glenn L. Martin Company near Baltimore, Md.

fields, quite unable to pose the problems, encourage the research, and utilize the results.

C. Government Activity: Techniques and Standards

1. U. S. Forest Products Laboratory

Several government agencies played a prominent role in the development of prefabrication during the thirties. One of these was the U. S. Forest Products Laboratory,[45] whose purpose it was to study the utilization of our forest resources and which had for some time been working on various types of glue and plywoods. Later it began to work on house construction, and in 1935 its first stressed skin plywood house was built, embracing a structural design that was to have a very great influence on the development of the industry. The stressed skin principle was not new, except to housebuilding; the idea was simply to build the wall panel as a box girder and thus use the surfaces of the panel in such a way that they, as well as the framing members, would carry a major part of the load. Though not new, the principle waited for its housing application upon the creation of the proper plywoods and glues. Stressed skin construction offered good possibilities for saving material, mechanizing wood fabrication, and lightening the structure, and it was therefore eagerly adopted by a number of prefabricators and was extensively exploited in war housing. The contributions of the U. S. Forest Products Laboratory to prefabrication had really just begun, however, for in the ensuing years the research carried out there dealt with many of the technical problems besetting manufacturers, for example, dust patterns, interwall condensation, and the bowing of panels due to changes in moisture content; and the work of the Laboratory with new materials and production techniques had great import for most of the firms in the industry. It is probably pertinent to remark that this publicly sponsored research organization served a unique role in an industry characterized by small companies which were generally incapable of carrying on any extensive research of their own.

[45] Madison, Wis. Established in 1910, and operated by the U. S. Forest Service, Department of Agriculture.

2. National Bureau of Standards

Another government agency which rendered technical assistance to prefabrication was the National Bureau of Standards, which in 1937 began a program of research in building materials and structures for use in low-cost housing. Testing procedures for such elements of the house as walls, partitions, floors, and roof were developed, and a large number of reports on the physical properties of various materials and systems of construction, some of them prefabricated to a large degree, have since been issued.[46] Work was also done on plumbing and heating equipment, on Simplified Practice Recommendations,[47] Commercial Standards,[48] and building codes. Ultimately this program of performance tests and related building studies may have a large effect on the writing of codes and specifications and on the whole development of better and cheaper methods of construction.

3. Federal Housing Administration

It is the Federal Housing Administration, however, which has probably been the most important single influence in setting standards for the construction of low-cost houses. Through its guides for rating mortgage risk the FHA established many criteria for house construction. Prefabricators who were trying to tap medium- and low-cost markets with a new product had to rely to a considerable extent on FHA mortgages for home financing. When a prefabricator's house was approved on a technical basis, the Washington office of the FHA issued an *Engineering Bulletin* proclaiming that fact and giving pertinent data. One result of this was to create a basis for evaluating the

[46] *Building Materials and Structures Reports*, U. S. Department of Commerce, National Bureau of Standards (Washington, 1939+).

[47] Aimed at eliminating waste through the establishment of standards of practice for stock sizes and varieties of specific commodities that are currently in general production and demand. Adopted voluntarily by industry with the assistance of the National Bureau of Standards.

[48] Aimed at establishing standard methods of test, rating, certification, and labeling of commodities and at providing uniform bases for fair competition. Adopted voluntarily by industry with the assistance of the National Bureau of Standards. Commercial Standard CS125-45 for Prefabricated Homes, accepted in 1945, was the first applying to the prefabrication industry. A revision, CS125-47, was brought out in 1947.

prefabricating systems commercially available. Yet, while the FHA has had a distinctly salutary effect in revising mortgage financing, in inducing banks to lend on prefabricated houses, and in establishing standards, the influence of its approval has grown so great that a new house manufacturer is now apt to be severely penalized without it. The importance of this institution increased steadily throughout the thirties, but it was only in the postwar period that it reached its present tremendous significance. It is perhaps not too much to say that FHA approval is now a matter of life or death to the prefabricator about to enter production with a new system, and in view of the power wielded by the FHA, its policy with respect to new developments in building has become a matter of considerable importance.

D. Government Activity: Prefabricated Construction

When we turn to a consideration of the various government agencies which entered into housebuilding directly, we find vast differences in approach, deriving chiefly from equally large differences in purpose. At one extreme there was the public housing program, first under the Public Works Administration and then under the United States Housing Authority, which was conceived in terms of highly permanent fireproof multifamily buildings having low maintenance, high physical standards, and long-term (60-year) amortization to make rents as low as possible. The program was aimed at rehousing slum dwellers and usually involved building in dense urban areas. For these and other reasons the public housing authorities did not regard prefabrication very seriously and did not use it at all until the advent of the war housing program.

1. Farm Security Administration

In contrast to this public housing program, the Farm Security Administration [49] was charged with promoting self-sufficiency, decreasing tenancy, and resettling migrants on the land. The FSA's approach was from the beginning characterized by a willingness to ex-

[49] Formed in 1937 to carry on the work of the Resettlement Administration and several other farm agencies.

periment, and its technical staff, which was decentralized into 12 regional offices and by comparison with the public housing program was relatively free from Washington control, emerged with many fresh approaches to construction. In 1938 the FSA built 100 farmsteads for sharecropper families in Missouri and achieved very low costs by prefabricating wall and roof sections and making use of a large proportion of unskilled labor. The price was $1,105 for a 24′ × 36′ five-room house, and $2,000 for a farmstead including house, barn, storage shed, privy, fencing, roads, and a well.[50] The following year 60 farmstead units of steel were ordered from the Tennessee Coal, Iron & Railroad Co., a United States Steel Corporation subsidiary, and were erected in Georgia, Alabama, and South Carolina. The houses, a little smaller than the wooden ones built in Missouri, cost 50% more.[51] In the west the FSA built whole communities for migratory farm workers and carried on a number of experiments with plywood and other unconventional construction in an attempt to provide migrants with something more substantial and more economical than a tent. Some 6,000 steel "minimum" units, 12′ × 14′, were built for this purpose. Though not related specifically to prefabrication, the planning and building of these integrated farm communities were among the agency's most significant contributions in the field of housing. By the end of 1940 the FSA had built more than 26,000 individual houses,[52] and at that time *The Architectural Forum* could write, "Today in face of a national emergency, Farm Security stands out as the agency most experienced in the work of building houses quickly and cheaply." [53] Its work continued into the war period and included in a dormitory project near Vallejo, Calif., one of the first uses of stressed skin plywood construction in two-story buildings.

2. The Fort Wayne Experiment

Still another approach was the widely publicized Fort Wayne Plan developed jointly in 1938 by the FHA, the Fort Wayne Housing Authority, and the PWA. The 50 single-family units comprising this

[50] *The Architectural Forum,* 69 (November 1938), 393–4.

[51] *The Architectural Forum,* 70 (January 1939), 68; *Architectural Record,* 85 (January 1939), 38–9.

[52] Including those built by the agencies the FSA had taken over (*The Architectural Forum,* 74 [January 1941], 13).

[53] *The Architectural Forum,* 74 (January 1941), 3.

project were built of stressed skin panels and rented for $2.50 a week. WPA labor was used in a factory rented and equipped by the Fort Wayne Housing Authority, and houses were placed in blighted areas on vacant lots which had been bought for $1.00 each, the seller being given an option to repurchase. This plan differed significantly from the public housing formula, and it inspired considerable controversy.[54] Its 480 sq. ft. houses were below USHA standards; it required demountable units in case the land was reclaimed by the former owner; it called for lighter construction and shorter amortization periods; it used WPA labor; and it involved private, insured financing. Perhaps the fact that this plan was not adopted elsewhere is evidence that it was not suited to the conditions and the times. It did, however, bring attention to another example of prefabricated construction.

3. Tennessee Valley Authority

Probably the most important government effort in prefabricated building during this period, at least from a developmental standpoint, was the work of the Tennessee Valley Authority with demountable sectional houses. Actually this work extended well into the war years, but it had its origin in an earlier period and is therefore discussed here. The TVA required temporary housing for the construction workers on its many hydroelectric projects and had for some time speculated about making good portable houses as an alternative to building mere shacks.

In 1934 Louis Grandgent, then chief of TVA's architectural section, proposed a scheme for building a house which could be separated into four or five sections each of such dimensions that it could travel safely by truck and trailer over public highways. After some experience with transporting conventional houses by barge, the sectional house idea was developed by the TVA staff under the supervision of Carroll A. Towne. In 1940 the first TVA sectional houses were built for transportation by truck to the site.[55] Sections measured $7\frac{1}{2}' \times 22'$

[54] See, for instance, Charles Abrams, "Fort Wayne Housing Plan Analyzed," *American City*, LIV (April 1939), 106; *National Association of Housing Officials News* (February 28, 1939), 9–11; (March 28, 1939), 21.

[55] In 1939 General Housing Corporation, Seattle, Wash., had begun manufacture of a sectional but otherwise conventional wood frame house. The four-room dwelling was made in two 12′ wide sections, completely finished and equipped

$\times 9\frac{1}{2}'$, were of wood frame construction, and weighed three tons. They left the factory with all electric, heating, and plumbing equipment installed, and arrived at the site completely finished even down to light bulbs and screens. Houses were finished at the site in as little as four hours by bolting together two or more sections. The next year the TVA's design was adopted by the Federal Works Agency for war housing, but in order to meet nationally standardized requirements, a pitched roof, hinged to let down during transit, was added. In 1942 the TVA began experimenting with designs that frankly recognized the house section as a trailer and used certain aspects of trailer construction. Weight was reduced by the adoption of stressed skin principles, and transportation costs were cut from 30¢ per section per mile to 23¢. These houses were trucked as far as 600 miles. Still later, when the Army erected several thousand of these houses at the atomic bomb project at Oak Ridge, Tenn., a boom crane was used to put sections in place instead of the jacks and rails that had previously been used. This kind of prefabrication, which reduced site labor to as little as 5–10% of total direct labor, was later to have considerable influence in several postwar designs, notably the Prenco and Reliance houses and the British AIROH house.

E. Commercial Development by Private Enterprise

While a number of non-profit and government institutions made significant contributions to the development of prefabrication, its widespread adoption on a commercial basis awaited the efforts of private enterprise, and it remained for some entrepreneur to organize a successful pattern of operations. In the early thirties one element of the business world, big business, saw the challenge of prefabrication and talked as though it were prepared to turn the gleam in the inventor's eye into a profitable operation. For reasons outlined previously, at least a dozen of America's largest corporations entertained the idea for a while, and a few stuck with it continuously. Among the big names were United States Steel Corporation, Great Lakes Steel Corporation, American Car and Foundry Co., Pullman Standard Car Mfg. Co., The Celotex Corporation, Johns-Manville Corporation, U. S. Gypsum Co., American Radiator & Standard Sanitary Corp., and

in the factory and trucked to the site (in the Seattle area) where it was bolted together. Average price, erected and with lot, $3,900; f.o.b., $2,980 (*The Architectural Forum*, 70 [April 1939], 286).

General Electric Company. Several of these companies went no further than to supply certain components to prefabricators in accordance with specifications. Some of the materials producers went to the extent of developing a house system, not infrequently a structure which reflected the attempt to find every possible use for that company's product. Only a few companies maintained a prefabrication research establishment that was more than a token effort, and these few did it on a budget that was meager compared to the research expenditures of equally large companies in other industries. However, most of these companies and a number of others retained advisors to keep in touch with current developments.

1. General Houses, Inc.

Related to the interest of big business in prefabrication were the proposals for at least two rather ambitious corporate structures. The first of these was General Houses, Inc., organized in 1932. Under the leadership of Howard T. Fisher, General Houses was to design, coordinate, and assemble standard parts to be produced for it by a number of prominent specialists. It took its pattern from the automobile industry, in which the nominal manufacturer usually acts more as an assembler than as an actual producer but does assume responsibility for coordinating the many elements involved and for providing a complete service to the customer. With unused capacity available in thousands of plants throughout the country, General Houses would need no plant and would have none; instead, parts were to flow from the specialized manufacturers via warehouses to the site where they would be assembled. The house was not to be standardized; it was to be custom built from standard elements. In many respects this pattern was followed, with the cooperation of several large corporations.[56] Research and

[56] Among others, Bethlehem Steel Co., Pullman Standard Car Mfg. Co., Curtis Companies Incorporated, American Radiator & Standard Sanitary Corp., Container Corporation of America, and Weyerhaeuser Timber Co. General Houses had an extremely simple corporate structure. Only one or two of the cooperating companies ever held any stock, and their stockholdings were nominal. After Pullman withdrew to concentrate on the expanding car business, Bethlehem Steel took over and for several years fabricated all the steel parts used by the company. Most of the millwork and other woodwork was made by Curtis right through to the war years, when Curtis fabricated complete panels for walls, floors, ceilings, and partitions for some of General Houses' war housing projects.

development were financed by General Houses itself and standard parts made to General Houses' specifications were purchased from suppliers as in the automobile industry. Beginning with a house of load-bearing steel panels (see Figure 9), General Houses changed in 1936 to a steel frame system with sandwich panels of cement asbestos sheet (exterior), insulation, and plywood (interior), largely in an effort to achieve lower cost. Architecturally the design was quite modern with a minimum of ornament, a flat roof, smooth exteriors, vertical battens, and a good deal of glass.[57] Up until shortly before the war General Houses built several hundred of these houses, an output far below its proposed mass-production levels. It had encountered a few technical difficulties such as interwall condensation, none of them serious, but had met with its largest problems in the realm of financing and marketing. The dealers came largely from outside the building industry because of opposition to prefabrication within the industry. In some respects, they could do a better job of retail merchandising, but they were severely handicapped by lack of practical building experience. Another major source of trouble was in obtaining suitable mortgage appraisals, a problem which derived largely from the unconventional nature of the house. General Houses revised its approach towards the end of the decade, partly for these reasons and partly because of increasing shortages in steel. Fewer designs were offered, wood was employed as a basic material, the roof was peaked, and the general appearance was made to conform with convention. About this time the defense housing program started, curtailing private building to a large extent, and General Houses changed its plans further, becoming one of the first prefabricators to participate in the war housing effort and influencing in part the use of prefabrication in war projects.

2. Houses, Inc.

The second of these grand ventures was Houses, Inc., started by Foster Gunnison in 1934 at the instigation of Owen D. Young, then Chairman of the Board of General Electric Company. Houses, Inc., would build no houses, but it would cooperate with other companies in the development of houses of several types. To this end

[57] Price in 1934, erected but less freight and cost of lot: four-room house, $4,500; six-room, two-story house with garage, $8,550.

it proposed to engage in research and provide assistance in the management and financing of housing enterprises. American Radiator & Standard Sanitary Corp. and General Electric Company were the companies which were to cooperate in the development work. Houses, Inc., was to own stock in other companies which would assemble and erect the dwellings. In 1935 there were two such affiliates, National Houses, Inc., which had a steel-frame steel-panel system, and American Houses, Inc., which was producing the Motohome.

The promotion of the Motohome was the biggest activity of Houses, Inc., that year. Engraved invitations to the first exhibition announced the "American Motohome" as "the prefabricated house that comes complete with food in the kitchen." In Wanamaker's New York store on April 1, 1935, President Roosevelt's mother untied the ribbon that bound the Cellophane-wrapped house.[58] The public found a house of steel frame and asbestos cement panels, with a flat roof, corner windows, and an exterior which frankly expressed the panelized construction. Inside was a mechanical core including plumbing, heating, and electrical equipment, the product of work by the Pierce Foundation and General Electric Company. The promotional campaign included not only store exhibits and demonstration houses such as those built in Westchester County that summer, but also extensive publicity in the press; Sunday supplements and trade papers alike carried illustrations of what a community of Motohomes would look like and what sort of truck would carry them from the factory to the site. In late 1935, however, there were several disputes among the backers[59] and the management of Houses, Inc., and, for reasons which were primarily personal, Foster Gunnison sold out his interest and went to New Albany, Ind., to found his own company. General Electric carried on Houses, Inc., for about another year without much success and then liquidated it.

3. American Houses, Inc.

Meanwhile, American Houses, Inc., which had had an independent existence of its own since its inception in 1933, continued on its

[58] 500,000 people are said to have visited the Motohome during a six-month exhibition.

[59] By October 1935 General Electric had bought out American Radiator's share in Houses, Inc., and owned it outright.

way under the leadership of its founder, Robert W. McLaughlin.[60] The Motohome, of which only about 150 had been sold, was abandoned.[61] Emphasis was placed on reaching the low-income market with a conventional product rather than the middle-income market with a "better than conventional" one.[62] In addition, American Houses radically altered its designs by adopting peaked roofs, wood sheathing, clapboard exteriors, and plywood interiors. The steel frame was retained for another two years, until 1938, when it was discarded in favor of conventional wood framing because the latter was more flexible, easier to use with other materials, and could be fabricated with less elaborate equipment in the plant. By the end of the decade American Houses' system was of traditional platform frame construction, and the extent of prefabrication had been reduced to precutting and partial preassembly of panels.[63] There was developing within the company at the same time a trend towards working through contractors who were building projects rather than selling through dealers to individual customers. While it was thus changing its pattern of operations, American Houses grew to the point where, at the beginning of the war, it was one of the leading prefabricators in the United States.[64]

4. Gunnison

In the course of the same period, Gunnison had also developed one of the best-known firms in the industry.[65] He had begun in a

[60] Now a member of the Board of Directors.

[61] Possible reasons: sales resistance to its appearance; its mechanical core required servicing by American Houses; it was overloaded with equipment manufactured by its original sponsors.

[62] The minimum Motohome was a single-story four-room house with garage selling at $4,950, erected but less lot. Other models were priced up to $15,000.

[63] *The Architectural Forum,* 73 (July 1940), 69 ff.

Later (1943) American Houses began to describe its business as a "refining operation," a stage between the manufacturer of raw materials and the contractor.

[64] One of American Houses' most successful projects was a 136-house subdivision for Bethlehem Steel Co. near Baltimore, Md., 1939–1940. The four-room house was priced, with lot, at $2,750. At about the same time American Houses was also building in another price range: garden apartments in New Rochelle, N. Y., to rent at $20 a room (*loc. cit.*).

[65] Starting in 1935 as Gunnison Magic Homes, Inc., the name was changed in 1937 to Gunnison Housing Corporation, and in 1944 to Gunnison Homes, Inc.

modest way, renting a small plant in which to produce his stressed skin plywood panel houses. The first of these, even though of traditional appearance, aroused a good deal of protest, but this stemmed mainly from local building people who saw their interests threatened. Opposition diminished and public acceptance grew as Gunnison and his houses became known. The 1937 spring flood of the Ohio River accidentally proved beneficial by showing that the houses, some of which had been immersed, were of sound construction and by giving Gunnison an opportunity to compete with conventional builders in a relief project undertaken by the New Albany Housing Authority, a project which measurably added to his prestige. Emphasis had, from the beginning, been on low-cost homes [66] sold through dealers to the ultimate consumer. There was a brief attempt at marketing through the building of housing projects under the Gunnison Village Plan,[67] but the overall trend was in the opposite direction, towards the evolution of a system of retail merchandising that would diversify sales risk by making many small sales to individual customers. Gunnison brought to prefabrication the ability and approach of an organizer and salesman. He was more determined than most prefabricators have been to break completely with the traditional operations of housebuilding and to draw his personnel and his manufacturing and marketing methods from fields characterized by true mass production. In retrospect his influence appears as a major factor in shaping one of the important marketing patterns of the industry.

5. The Nature of Efforts by Big Business

A brief account of the early phases of several enterprises can hardly do justice to the effort expended on prefabrication in the thirties, but a few examples may suffice to show the kind and extent of activity by big and little business.

Regarding the large corporations, it might be said that their re-

[66] In 1936 a four-room, 24′ × 32′ house sold for $2,650 erected but less lot. The "Miracle Home" offered in 1939 was priced at $2,950; $350 down, $21 a month.

[67] Under this plan a local corporation would acquire land, erect a community of Gunnison homes, and manage it after completion. 80% or in some cases 90% of the total value of the completed project was to be provided by an FHA-insured mortgage. The balance would be represented by a stock issue of which Gunnison Housing Corporation would own a portion, the rest being held by local investors.

search was generally biased by some motive other than the industrialization of housing; often they designed a house to use the maximum amount of whatever material they produced. This is not to deny that the materials and equipment producers, who, of all the elements in the building industry, were the only ones capable of financing research on a large scale, did make great contributions in improving their own products. There also was significant progress in mechanical, electrical, and heating equipment, and in insulation, wallboards, flooring, roofing, and glass. But effort at the integration of parts, research in house design, and studies in construction techniques—these were largely neglected. Development work by large corporations in prefabrication remained embryonic; rarely, if ever, was an idea carried through to the pilot plant level. On the matter of distribution there was little significant activity. The idea that an organization for mass distribution of houses would have to be established before there could be any mass production had nodding approval in theory but little application in practice. Grandiose promotion schemes there were, but these should not be confused with serious attempts at establishing a marketing pattern, arranging for financing, meeting code difficulties, and overcoming problems at the site. This is not meant as an indictment of all the large corporations; some put a good deal of effort into developing their products and struggled for a while with the idea of selling a house, but ultimately they retired for the most part to selling prefabricated components, usually for non-residential construction. The subsidiaries of Great Lakes Steel Corporation [68] and American Rolling Mills Company [69] may serve as illustrations.

Yet it is probably fair to remark that the large corporations never really threw their full resources into the fight. To a certain extent this may have been a manifestation of the inertia of bigness. But probably more than this it was a reflection of the organization of the building industry. There is, first of all, a basic schism of long standing in this industry.[70] On the one hand are the manufacturing and construction interests whose profits stem from the *production* of buildings, and, on the other, the rentier and realty interests whose profits stem from the *ownership* of buildings (and land). Where a high rate of production might lead to a disturbance of established values a conflict of interests is apt to occur, and the position of the

[68] Stran-Steel.

[69] Steel Buildings, Inc., and The Insulated Steel Construction Co.

[70] James Marston Fitch, *American Building; The Forces That Shape It* (Boston: Houghton Mifflin, 1948), pp. 334–9.

rentier interests who control land and home financing is in this case a very strong one. Furthermore, the nature of the housebuilding process up to now has been such that no single person, organization, or even industry has a sufficient stake in the completed house (in terms of dollar value) to justify research and development in the fabrication, assembly, and overall construction of the house itself and the creation of coordinated marketing processes.[71] Because his own stake in the house is small, no supplier makes a serious effort to reduce the use of his product or service—though this might lead to greater overall efficiency. Each attempts rather to increase its use, firm in the knowledge that what he does makes little difference in the total cost. This attitude has been seen throughout the field, in labor organizations, materials producers, and fixture and equipment manufacturers alike. There has been no element in the housebuilding industry with sufficient motivation and with sufficient power and means of control to initiate fundamental changes in the fabrication and construction processes and carry them through to the final product. Another factor in the housing field which might deter a large corporation from directing its research efforts in that direction is the likelihood that marketing outlets for the house package would be in direct conflict with existing marketing outlets upon which the company might be in large measure dependent. There was rarely sufficient likelihood of profit to warrant taking such a risk. In addition, experienced salesmen were well aware that public attitudes about the home are more strongly entrenched than attitudes towards other less historic and less emotion-loaded products.

6. The Role of Small Firms

Because of the relative inactivity of the large corporations the role of the small entrepreneur, that is, the innovator of relatively

[71] This point has been made many times, notably recently by C. F. Rassweiler, Vice-President for Research and Development, Johns-Manville Corporation, in a talk before the Annual Fall Meeting of The Producers' Council, Inc., New York, September 30, 1948; and by Robert W. McLaughlin, architect, in a talk at the Massachusetts Institute of Technology, February 26, 1948. McLaughlin stated that his studies of a "typical" 750 sq. ft. low-cost house showed that the largest single element of cost, dimension lumber, represented less than 10% of the total final cost. By the same token, one may find here one of the keys to a successful approach to prefabrication—capital aggregations and competent staffs large enough to bring vertical integration to the whole process of housebuilding.

est financial resources, was a quite important one. There were lly scores in this category, but the vast majority never got beyond the initial stage of invention. Throughout the decade there continued the almost naïve belief that the invention of some joint or wall section was the answer to the problem. Some went further and designed floor, roof, and partition details; a still smaller group went on to consider the mechanical equipment in the house; and only a few attempted to outline and organize a pattern of operations that included all phases of the enterprise including distribution. The number of would-be innovators in this period was so formidable that it would be hopeless to attempt here a review of even the better half. Instead we shall look briefly at the field as a whole and point out the broad trends.

F. General Trends and Characteristics

1. Ideas and the Public Mind

One clue to the kind of thinking that was going on may be found in the Symposium on Prefabrication sponsored in 1935 by Richardson Wright, editor of *House and Garden.* Gathered for dinner and debate were some dozen people who had achieved a certain eminence in the field. The discussion ranged over many aspects of the prefabricated house: its advantage over conventional houses, its optimum useful life, the problem of financing, the question of modern design, prefinishing versus site finishing of panels, etc. The stenographic report of the Symposium [72] contains some remarks that are interesting in retrospect:

John Ely Burchard, vice-president of Bemis Industries, Inc., Boston:

> It is very important that provision be made for financing the houses, and the prefabricator cannot dump the problem in the lap of the banks. Unquestionably the prefabricated house will be a sounder and more uniform security but the industry itself must make some arrangements for financing.

Raymond V. Parsons, consulting engineer, Johns-Manville Corporation, New York City:

[72] *House and Garden,* LXVIII (December 1935), 65–72.

It can almost be taken for granted that when good prefabricated houses become a fact their architectural style will be different from the quaint English cottages and Cape Cod Colonials that are the present favorites of the speculative builders. The idea that we should take new and better building materials and mould them into the lines and textures of old materials possessing any number of shortcomings is abhorrent.

Howard T. Fisher, president of General Houses, Inc., Chicago:

The final decision, in the matter of design, will of course depend on what the public wants. But in everything else the public has shown its preference for the best in modern design, and I doubt if they will pay extra for faked imitations of the past when they buy their houses. As a matter of fact, I believe the greatest selling point these houses will have in the next decade will be their style.

Robert L. Davison, Director of Housing Research, John B. Pierce Foundation, Raritan, N. J.:

I can't agree with that [Fisher's statement that a 'sloping roof becomes economically unsound because it is too inflexible']; it depends on the material used. We have worked with one material where a flat roof was the only logical solution, and now we are working with a material which cries out for a pitched roof.

Fisher (on what the useful life of the prefabricated house should be):

I think if the cost could be correspondingly reduced it should be as short as possible—up to a certain point! . . . It would obviously be more economical, due to the obsolescence factor, to buy a house that would last, say, fifteen years, and which would cost only 60% of a house that would last thirty years, if that were possible. We have been building—this is particularly true of England—for too great a period of time. . . . What would be the sense in building a refrigerator to last 100 years when you know improvements will be constantly coming into the market?

This may have been the first symposium on the subject; it was by no means the last. The press, lay and technical, was very generous in its attention to prefabrication and produced words much faster than prefabricators did houses. The inventor's desire for publicity was of course abetted by the editors and apparently even by the general public, whose curiosity and interest in the home made it receptive to most of what was said. If a house suspended from a mast was no longer a sensation, then perhaps a mobile house was. The influence of the trailer craze that hit America about 1937 spread into housing circles, and it was not long before someone had figured out how to cure our social ills with mobile dwelling

units. There were houses of copper and of cotton; houses could be hauled down Main Street or floated down a river; and a hundred names, from "prefabs" to "motorized zipper housing," were bestowed upon these proposals. Probably all this publicity did more harm than good. It led many people to believe that some miracle would solve the problem, and at the same time it confused them about the nature of that miracle, what the prefabricated house looked like, and where it could be bought and for how much.

2. External Obstacles

Prefabricators encountered a number of external obstacles as they tried to bring enterprises from the experimental stage into commercial production. Such obstacles stemmed in part from local materials dealers who might decline to sell to the prefabricator's dealer certain items needed to finish the house, or to grant him a line of credit; or who might bring pressure on the local building inspector not to grant a building permit. They were due in part, also, to organized labor, not so much because of actual fights, although these, too, occurred, as because of passive resistance and refusal to handle prefabricated material. The banks and local FHA offices presented another type of obstacle in their reluctance to lend or insure loans on prefabricated houses and in their tendency to make low appraisals for mortgage purposes. Not the least of a prefabricator's troubles were those arising from local building codes written in terms of specification rather than performance, and very often excluding his type of construction. Where the code contained a clause permitting new types of construction if the building inspector was satisfied, as the result of a test, that the system was adequate, such tests had to be made at the prefabricator's expense. Sometimes one inspector would refuse to accept results of a test made in another locality, or there would be a lengthy court case involving a code issue. Not infrequently the mere prospect of such obstacles was enough to dissuade the prefabricator from marketing in a certain area, and those firms hardy enough to pioneer in this respect were required to spend a major part of their energy simply in overcoming the various types of external resistance.

3. Trends in Design

At the Chicago World's Fair of 1933 the modern house exhibit contained only three dwellings which were prefabricated to any important extent: General Houses' house of steel; Stran-Steel's house embracing that company's close-spaced frame system, and the Rostone Corporation's house of precast synthetic stone. This was not a complete representation of the embryonic house manufacturing industry, nor was it especially successful in selling the idea of prefabrication. At about the same time the files of Bemis Industries and of United States Steel Corporation's prefabrication advisor contained some 40 or 50 American systems which had been proposed and not yet abandoned. By the end of 1935 *The Architectural Forum,* already watching prefabrication as a parent might watch a precocious child, could list some 33 systems which were supposed to be commercially available.[73] Of these, 16 were steel frame construction using panels of various materials such as asbestos cement, precast concrete, steel, or composition board; five were of steel load-bearing panels; eight were of precast concrete; one was of precast gypsum; two were of wood frame; and only one was of plywood. Of 25 commercially available systems which the *Forum* [74] reported in 1938, 15 used steel, two used plywood, and precast concrete was still a challenge not to be abandoned, with five systems in use.

By the end of the decade a swing away from steel was visible. On the technical front, the combination of insulation, condensation, and corrosion problems had at least temporarily defeated many of the proponents of the steel house. Another and more formidable obstacle was the problem of selling houses fast enough to justify a large investment in plant and equipment. No matter how well steel might be suited to industrialized production methods, these methods usually required a very substantial capital investment in manufacturing facilities. Consequently, production at low volume would be high-cost production, and costs could not be brought down through mass production until a system of mass distribution had been established.

Where was the vicious circle to be broken? Perhaps by using a material that would be economical even at low volume, although it might lend itself less to industrialized methods and ultimate cost

[73] J. André Fouilhoux, "Prefabricated Units for the Home," *The Architectural Forum,* LXIII (December 1935), 544–76.

[74] *The Architectural Forum,* 68 (February 1938), 66, 70.

reduction. Wood was such a material, and it was increasingly adopted. Indeed, this was one of the outstanding trends in prefabrication during the latter part of the thirties—the abandonment of metals and of grandiose schemes which had come to nothing, for the use of wood on a more modest scale in a way that involved but a limited amount of prefabrication. Whether the metals would, in the end, prove to be the most useful materials for the industrialized production of housing was for history to tell. Many held out hopes for their success in the long run, but they had received at least a temporary setback.

4. The Achievement

By 1940 there were not more than 30 firms [75] in existence which were manufacturing and selling prefabricated houses on a steady basis.[76] The great bulk of the production was of a sort that involved comparatively little in the way of new materials or prefabrication: precut and panelized wood frame (dry-wall) construction (see Figure 10). All in all, excluding the precut houses, not more than 10,000 prefabricated units [77] were produced between 1935 and 1940, or less than 1% [78] of all the single-family homes built in nonfarm areas during that period.

[75] The files of the Bemis Foundation would indicate this.

[76] Among the more prominent of these were:

Adirondack Log Cabin Co., Inc., New York, N. Y.
Allied Housing Associates, Inc., Langhorne, Pa.
American Houses, Inc., New York, N. Y.
Crawford Corporation, Baton Rouge, La.
Ivon R. Ford, Inc., McDonough, N. Y.
General Houses, Inc., Chicago, Ill.
Gunnison Housing Corporation, New Albany, Ind.
Harnischfeger Corporation, Port Washington, Wis.
E. F. Hodgson Co., Boston, Mass.
Houston Ready-Cut House Co., Houston, Tex.
National Homes Corporation, Lafayette, Ind.
Pease Woodwork Company, Inc., Cincinnati, O.
Southern Mill & Manufacturing Co., Tulsa, Okla.
Willisway Construction Co., Chicago, Ill.

[77] No precise figures could be found. This is the estimate of Miles L. Colean, *American Housing; Problems and Prospects* (New York: Twentieth Century Fund, 1944), p. 147.

[78] *Housing Statistics Handbook*, p. 6.

5. Summary

These, then, were the characteristics of prefabrication in the thirties: a huge amount of interest, but few houses; active participation in various ways by non-commercial institutions, government agencies, and the large corporations; a profusion of structural ideas only a few of which were technically and economically sound; and the failure of these to achieve real commercial success on a large scale because no one had yet brought together enough intelligence and capital to develop an integrated building organization whose operations extended from the procurement of materials through manufacturing to selling, financing, erecting, and servicing the home.[79] Among the firms which sold houses on a continuing basis there were several noticeable traits. There had been a retreat from steel to wood, and from flat roofs and battens to Cape Cod cottages. On the average, more and more was being included in the house package, though as yet few companies had gone beyond the shipping of wall panels and either panelized or precut floor and roof members to the packaging of a complete house with all materials and mechanical equipment. There was, furthermore, a very minimum of prefinishing. And, in the field of distribution, there were at least two emerging patterns, besides those of the firms which catered to such specialized shelter needs as vacation cottages and oil field dwellings. One was the dealer organization, exemplified by Gunnison, through which many dealers sold houses one at a time to a customer at a time; the other was the array of contractors and operative builders through which American Houses was selling its product in large groups to an anonymous market.

G. The Analogy with the Automobile

One other characteristic of the thirties which deserves mention is the tendency to draw an analogy with the automobile industry; it is one that has dogged prefabrication throughout most of its history, but had an especially large influence in shaping the theories of this period. Writers never tired of pointing out the example set by Detroit in the mass production and mass distribution of automobiles and never ceased lamenting the fact that the housebuilders had not

[79] For an outline of reasons for failures in prefabrication, see John E. Burchard, "How Better Houses Will be Built," *Technology Review*, 39 (July 1937), 415–20.

wrought similar miracles. But in their haste to draw the analogy and in their impatience with the building industry, they often forgot to consider important factors. An obvious one is the bulk and weight of the product, which directly affect the optimum degree of factory assembly and the optimum factory size and location.

1. Subsidies and Land

Perhaps not so obvious is the fact that the housing industry had yet to receive any such subsidy as the transportation industry had received—the canals and railroads in the form of land grants, and the automobile industry in the form of roads and highways.[80] Certainly, transportation depended no more definitely upon cheap land than did housing. A public program to plan land use and write down high land costs for housing might therefore be defended as was an equivalent subsidy. Indeed, such an opinion was expressed, not by long-haired radicals, but by the business magazine, *Fortune,* which in 1932 wrote: [81]

> The $2,000 house on the $2,000 lot is no answer to the demand for a $4,000 dwelling. Obviously, however, industry cannot alone insure the stability and initial economy of the land. The fact is that aside from temporary conditions due to the present emergency, land in or near urban centers where the housing need is greatest will not be available at the price necessary. The human inclination to speculate in land values will see to that. Nor will neighborhoods protect themselves (and their mortgagees) against blight of their own accord. Only some form of governmental intervention can secure the ends desired. It is therefore obvious to the merest selfish considerations of private profit that the housing manufacturers must associate themselves in their land purchases and in the planning of their houses on the land, with some organization having governmental powers to condemn land in the first place and governmental powers to protect it afterwards.

Our concern is not the soundness of this argument, but merely the issues it raises: first, unlike automobiles, houses are not complete until they are placed on land, and the price of land is a part of the total over which the manufacturer has no control; second, public

[80] Before 1927 motor vehicle owners paid less in motor vehicle taxes than "their share" of road and street costs (*Automobile Facts and Figures,* ed. 22 [Detroit: Automobile Manufacturers Association, 1940], pp. 48–9). The public powers used in road construction are much more important in this respect, however, than the financial assistance itself.

[81] *Fortune,* VI (July 1932), 107.

intervention and public subsidy have played a part in the industrialization of more than one aspect of the national economy, and in comparing the industrialization of shelter with that of other commodities, they should not be overlooked.

2. The Character of the Innovation

A third point often neglected is this: of the new products which have successfully been mass produced and distributed, most have either offered a quality or service that differed substantially from that of existing objects intended for the same purpose, or else they have succeeded in performing a service that no previous object provided at all. The radio, the telephone, and the automobile are all examples of the latter. True, there were means of communication and transportation at the time of each of these inventions, but the new service was radically different from any existing at the time.

Now consider the house. With one or two possible exceptions, no prefabricated house has yet provided shelter services that a conventionally built house could not duplicate. The recent inventions which have entered the home, such as sanitary facilities, electric lighting, cooking and refrigeration equipment, convection and radiant heating systems, air conditioning, dish- and clothes-washing machines, all could be and have been a part of the house built at the site by traditional methods. For a long time, conventional houses have been able to provide perfectly adequate shelter; they have been strong enough, have protected the human body from the elements, and have enabled it to maintain a comfortable temperature in an environment which is visually and acoustically satisfactory. The chief problem has been the economic one of providing the mass of the population with such housing. Special factors occasionally favor the prefabricator—remoteness of the site, importance of saving time or labor at the site, or speed in selling, for example; but these are unusual. Thus he has had to offer a product whose principal reason for being purchased was that it was claimed to be cheaper than a house of the same quality built by traditional methods.

This is not at all the situation which faced the early automobile manufacturers.[82] No horse, no matter how high priced, could do

[82] Mark Adams, "The Automobile; A Luxury Becomes a Necessity," in Walton Hamilton et al., *Price and Price Policies* (New York: McGraw-Hill, 1938), pp. 27–81.

what a car could. Conversely, there were many people who would buy a car, even at a cost of several thousand dollars, simply because it would provide excitement and exclusiveness. For more than ten years the automobile manufacturers exploited their product's role as a luxury commodity and sought to give cars more weight, power, comfort, and brass ornaments to meet the demands of those who could afford them. It was not until Henry Ford began his systematic move to reduce prices in 1907 that the trend was reversed, and even then Ford had no competitors for a number of years. During the period of greatest expansion in the automobile industry the demand for the services that only a car could give—immediately available mechanized transport, speed, convenience, a new freedom, and a new mark of prestige—was so great that firms were able to finance their expansion largely by requiring deposits from their dealers in prepayment for deliveries. Later the industry was in a position to use its profits for expansion and had no great need for recourse to the banks and the stock market. What a different course has marked the initial stages of the industrialization of housing!

3. The Question of Durability

At least one other factor ought to be considered in comparing the mass production of houses with that of other goods: the life of the product. From the great durability of housing arises the circumstance that the prefabricator must compete not only with the conventional builder but also with the vast supply of existing housing, which at any time far exceeds the annual production. From this great durability also stems the feast and famine character of housebuilding, with which both those in the industry and those who would enter to revolutionize it must reckon. We may remember that the transition from a situation in which demand represented primarily first purchases to that in which demand is chiefly for purposes of replacement was achieved fairly smoothly in the automobile and radio industries because of the relatively short life of the product. Through a combination of technological obsolescence, style obsolescence, and physical depreciation, the average life of the automobile was established at about nine years [83] and that of the radio

[83] C. F. Roos and Victor Von Szeliski, "Factors Governing Changes in Domestic Automobile Demand," *The Dynamics of Automobile Demand* (New York: General Motors Corporation, 1939), p. 48.

at about seven years.[84] Compare this with the life of the house, which is often roughly estimated at 70 years, but which in many cases is known to exceed 100 years. Suppose it were possible to rehouse most of America with manufactured homes; would the industrialized housing industry then be able to readjust itself to producing primarily for a replacement demand? Could it reduce the life of the house and still produce a salable product? What about the cultural values that a house symbolizes—do these affect the nature of a product which has a long history and tradition and is not just the child of an advanced technology? What about the land to which houses must be attached, and the ultraconservative branches of finance and law which deal with land?

These and other questions have to be considered in attempting an analogy between the mass production of houses and of automobiles. Any comparison which neglects such problems can at best be superficial.

V. 1940–1945: The War Period

Just as the prefabrication industry was struggling to get on its feet, the defense housing program hit it and knocked it off balance with a whole new set of problems. Instead of a future of slow development through concentration on key areas of difficulty, such as distribution, prefabricators were faced with the prospect of a huge market or practically none, depending on whether or not the federal agencies[85] in charge of the war housing program could be convinced of the industry's capacity to do a major part of the job.

[84] Julius Weinberger, "Basic Economic Trends in the Radio Industry," *Proceedings of the Institute of Radio Engineers*, 27 (November 1939), 708.

[85] The War and Navy Departments, the Maritime Commission, the Federal Works Agency—which had inherited the United States Housing Authority and the Public Buildings Administration—the Reconstruction Finance Corporation, and the Farm Security Administration were all active in the new construction aspects of the defense housing program during its early history. On February 24, 1942, the President ordered the establishment of the National Housing Agency which took over the housing functions of 16 non-military government agencies and units.

In the early days of the program there was more than a little skepticism expressed in government quarters. The failures of prefabrication in the preceding decade remained more firmly in mind than the occasional successes, and certainly instances of the latter sort had been of a modest rather than an overwhelming nature. But prefabrication offered potential advantages, and after a good deal of investigation and debate one of the agencies, the Public Buildings Administration, arranged a demonstration project at Indian Head, Md., where the prefabricators were to show what they could do. In the spring of 1941 contracts for 650 units went to 11 companies,[86] several of them without previous experience, which were to compete in the erection of demountable houses on sites provided by PBA. The systems represented were chiefly of plywood, insulating board, or plasterboard on wood frame, although in spite of the materials situation two firms used steel for the exterior wall. As a demonstration project, Indian Head was not a great success. By the time it was actually under construction some 13,000 prefabricated houses were already being built or on order.[87] Furthermore, the performance of the inexperienced firms was not a credit to the industry as a whole, and the problems at the site, particularly in the joining, fitting, and alignment of panels, served more to show the prefabricators their own weaknesses than to disprove the case for prefabrication in general. It was shown, however, that the prefabricators could produce at a price competitive with that of the conventionally built house, especially when salvageability was taken into account. An average performance in demounting the house, transporting it 40 miles, and reassembling it cost $474 and showed that on a dollar basis 95% of the house was recoverable.[88] Some of the actual projects which got under way before the demonstration houses at Indian Head had been started were more successful. A large project in Vallejo, Calif., of about 1,000 Homasote and 700 plywood houses was one of the best and clearly demonstrated the possibilities of

[86] Allied Housing Associates, Inc., General Fabricators, Inc., Harnischfeger Corporation, E. F. Hauserman Company, Home Building Corp., Lockwall Houses, Inc., National Homes Corporation, Sears, Roebuck and Co. with General Houses, Inc., Standard Houses Corp., Tennessee Coal, Iron & Railroad Co.

[87] *The Architectural Forum,* 75 (August 1941), 107.

[88] *The Architectural Forum,* 75 (September 1941), 189 ff.

prefabrication in a big development.[89] In 1941 prefabrication was for the first time on a mass-production basis. More than 18,000 units were built, probably more than had been produced in the entire preceding decade.

B. Factors Favorable to Prefabrication

Prefabrication was used in the war housing program principally because of three requirements: speed, demountability, and the reduction of on-site labor and congestion to a minimum. These requirements, arising out of special situations, did a good deal more to bring prefabrication methods into the picture than did the prewar performance of prefabricators in producing housing under normal circumstances. Although the industry had produced thousands of permanent homes in the thirties, it had not earned a reputation for unusual ability in this field; there were no outstanding firms of great achievement, and consequently the great bulk of permanent housing built during the war period, whether privately or publicly financed, was constructed at the site by conventional methods or by site-fabrication techniques. When, however, there was need for obtaining permanent housing very quickly near a war construction job or in a locality short in materials or building labor and supervision, prefabrication often was adopted. And as it became evident that shifting needs would be encountered, a considerable volume of demountable housing suitable for long-term use was built, most of which was prefabricated. Prefabrication was also used in areas where it was necessary to keep site labor to a minimum for security reasons, such as at the atomic bomb projects. After mid-1942 almost all publicly financed housing was of a temporary[90] type. Not only was it thought that further migration into crowded production areas would be, in most cases, of short duration, but it became evident that as the shortage of materials and labor grew increasingly acute the standards of the buildings would have to be lowered. This brought about such developments as a decided lightening of the structure,

[89] William W. Wurster, project engineer on this project, reserved the right to use entirely experimental design and construction on 25 of these units. It should be noted that the construction cost of these 25, built by three local contractors, was under $2,850 each, as compared with more than $2,900 for the regular project units.

[90] To be distinguished from *demountable* housing.

the exterior use of sheet materials not suited to the weather, the elimination of as much metal as possible, and the sacrifice of space. It also brought about the extensive use of stressed skin (prefabricated) construction in an effort to save framing lumber and gave impetus to dry-wall construction (much of which was also prefabricated), which was faster and spared critical materials.

C. Signs of Prefabrication's Growth

There were a number of signs of the growth of prefabrication during this period. One was the number of different types of buildings to which the techniques were applied: warehouses, hangars, two-story row housing, schools. Another was the amount and scope of speculative thinking and controversy. On the technical front the idea of the panelized versus the sectional house was being discussed, along with some variations such as the folding house. Notoriety attended a number of proposed designs: Martin Wagner's igloo-shaped house of steel, Buckminster Fuller's cylindrical house made out of a grain bin (see Figure 11), William Stout's folding house, Wallace Neff's unprefabricated but interesting hemispherical house made of concrete sprayed onto an inflated balloon (Figure 11), and the Palace Corporation's suitcase house (see Figure 12). Even early in the war the postwar house was a favorite topic for discussion, and a glance through the architectural and homeowners' magazines of these years would show how extensively the ideas of prefabricated closets, bathrooms, and mechanical cores had taken hold.

The concept of overall modular design also had increasing acceptance, in theory at least, and was reflected in such diverse plans as those of the Federal Public Housing Authority, Homasote Co., Ratio Structures, and General Panel Corporation of New York. And in the realm of distribution there was much speculation over the future pattern of the industry. When *The Architectural Forum* hypothesized that in an integrated building industry the prefabricator would sell to large developer-builders,[91] Foster Gunnison was quick to reply that no such pattern could succeed and that the necessary diversification of sales risk could be had only if the prefabricator

[91] *The Architectural Forum*, 77 (October 1942), 79–80.

sold to a great many small dealers.[92] Vaux Wilson announced a plan to sell his Precision-Built Homes through the department stores because of their vast experience in merchandising. Still another sign was the amount of interest in prefabrication shown by organized labor. The CIO, which in the years just before the war had made small inroads into the AFL's building industry territory, talked in big terms of the industrialized production of housing and the industrial form of unionism that would come with it. A good many wartime prefabricators had CIO shops, but in spite of a lot of conjecture about AFL-CIO conflicts in war housing there was little actual trouble. In light of the postwar developments to date, the CIO's invasion of the housebuilding industry seems to have been largely a temporary affair.

Another sign of the industry's growth was the formation in 1942 of the Prefabricated Home Manufacturers' Association, set up to disseminate information, establish industry standards, study distribution problems, improve manufacturing methods, make cost and accounting studies, and serve as a medium for the exchange of ideas.[93] *Prefabricated Homes*,[94] a monthly trade journal similarly aimed at giving the public a clear and favorable picture of the industry, first appeared in April 1943, instigated at least in part by PHMA. In September 1943 PHMA changed its name to the Prefabricated Home Manufacturers' Institute and expanded to include 12 charter members, with Walter Ahrens of Southern Mill & Manufacturing Co. as president. Among the first things for which PHMI fought were certain changes in the FPHA plans on which, since September 1943, all prefabricators had had to bid for war housing.

Other indications of growth in the industry were to be found in the number of active firms and their figures on output. Neither of these statistics is ever very precise because the lines between what is and what is not prefabrication and who is and who is not an active prefabricator are so hard to draw.[95] Even so, a few such figures will give a rough idea of the picture. As against not more than 30

[92] In an open letter to *The Architectural Forum* for the Prefabricated Home Manufacturers' Association, November 13, 1942, in the files of the Bemis Foundation.

[93] The National Association of Housing Manufacturers, representing a few of the more unconventional and newer companies, was organized in February 1947. Both are discussed in greater detail in Part II.

[94] From January 1948 until October 1949 the magazine was known as *Prefabrication*. It is no longer published.

[95] Lists of active prefabricators prepared by different sources at about the same time have differed by as much as 100%.

active firms in early 1940, there were at least 100 firms in production by the end of 1941.[96] At that time a government investigating committee which inspected 35 of these plants reported that there was a "reasonable certainty" of obtaining 27,450 units from the factories visited, in quantities of 100–2,000 each, within 90 days from the time orders were placed.[97] By April 1943 *The Architectural Forum* could assert that "there are now well over a score of prefabrication plants that have each manufactured more than a thousand houses, and many of which are now fabricating at the rate of several hundred a month."[98]

D. The Contribution of Prefabrication

A final summary of wartime prefabrication might credit the industry with 200,000 units.[99] Of these, 116,390 were publicly financed under the Lanham Act;[100] 16,000 were exported under lend-lease;[101] some tens of thousands were built by the Army and Navy at atomic energy centers and American and overseas bases; and a comparatively minor portion went into privately financed housing.

But big as this 200,000 figure may have been to an infant industry, it still represented but a small part of the total of approximately

[96] *The Architectural Forum,* 76 (February 1942), 83. A list of manufacturers and systems published by the prefabrication subcommittee of the Central Housing Committee on Research, Design and Construction in February 1942 included about 200 prefabricators.

[97] *Ibid.,* p. 82.

[98] *The Architectural Forum,* 78 (April 1943), 72.

[99] *The Architectural Forum,* 84 (April 1946), 137. *Fortune, XXXIII* (April 1946), 127, uses the same figure, but probably obtained it from *The Architectural Forum.*

[100] This represents about 25% of the war housing built with Lanham Act funds. Of these, 104,862 were family dwellings and 11,528 were portable shelter units designed for family use. Of the family dwellings, 1,428 were permanent, 66,901 were demountable, and 36,533 were temporary. About 77% of the 104,862 family units were fabricated in off-site factories and about 23% in on-site shops. All the portable shelter units were factory fabricated. Source: Housing and Home Finance Agency, in a letter to the Bemis Foundation, March 1948.

[101] Early in 1945 the FPHA, acting for lend-lease, contracted for 30,000 units. When lend-lease terminated, 16,000 of these had been started or completed. The rest were not produced. Great Britain received 8,600 on lend-lease; France bought the balance of 7,400 from FPHA. Source: Office of International Inquiries, Housing and Home Finance Agency, in an interview, June 4, 1948.

1,600,000 war housing units provided by new construction.[102] It is true that prefabricators made a major contribution in supplying housing quickly in a number of key areas and in meeting the requirements of special circumstances, but in the overall picture it remains a fact that by far the largest part of the war housing was built at the site by various techniques ranging from the conventional to the very advanced. Large projects made it possible to embrace many aspects of mass production at the site, such as standardization, specialization of labor, and highly planned scheduling of processes and material flow. Such projects also encouraged the use of power tools, jigs, conveyers, cranes, and other paraphernalia of factory production. Viewed in this respect, the war probably did more in rationalizing and improving the efficiency of on-site construction than it did for fabrication techniques in the factory, and it has been contended by some that, relatively, prefabrication was thus pushed back.

The credit for this progress in methods does not all belong with the conventional building industry. In a number of ways the development of site-fabrication techniques relied upon similar techniques used in the factory of the prefabricator who should, therefore, be given some credit. This development also resulted in part from the efforts of the government which did a considerable amount of research on site fabrication with its own technical personnel and educated a good many builders in the use of better methods. Yet the contributions of the "established" prefabricators (as of 1940) in "know how" were perhaps less valuable than their general knowledge of the building operation. This may be a sign of their weakness at the beginning of the war period, for other firms with little or no previous experience in prefabrication found it possible to enter the field and to build quite as readily, quite as successfully, and quite as profitably, as the established prefabricators. It is probably also an illustration of the fact that emergency production for a single consumer—a government at war—requires a pattern of operations very different from that suited to the private sale of houses in normal times. To be sure, in industries other than housing persons with no previous experience in the field were successful operators, notably, for example, in shipbuilding. But it is hard to think of an industry in which this was so markedly the case as in prefabrication. After a decade or more of gestation, the industry had not arrived at the point where it could make a really unique and major contribution

[102] *Housing Statistics Handbook*, p. 162, Table A; and *Public Housing; the Work of the Federal Public Housing Authority* (March 1946), p. 8.

to an important war problem. This reflected not so much the incompetence of the industry as the extreme complexity of the problem and the relatively small scale of the effort with which it had been attacked.

E. The Effect of the War on Prefabrication

The war had a very positive effect on prefabrication. For the first time production operations were put on a really large-volume basis (though not always a steady one). A good deal was learned about design and manufacturing techniques. Many firms attained strong financial positions, and many new enterprises entered the field. These and the signs of the growth of prefabrication discussed above point to the positive effects of the war period on the industry.

But no evaluation of the effects of the war on prefabrication would be complete if it did not include the harmful as well as the beneficial. While the war gave impetus to the growth of prefabrication, it pushed productive capacity beyond the industry's ability to distribute through any of the channels it had thus far established. It aggravated the unbalance between the prefabricator's ability to produce and to distribute. Furthermore, it made the marketing problem more difficult because it gave the public a bad impression of the product. Whereas the prewar prefabricated house may have been suspect as an interesting freak, the postwar product was often stereotyped in the public mind as a dreary shack. A consumer opinion poll conducted by the Curtis Publishing Co. in August 1944 [103] showed that while 74.5% of those interviewed had heard of prefabricated houses, only 17.2% of these would consider buying one to live in all year round. The reason given most frequently by the potential homeowner for not buying a prefabricated house was lack of strength. Obviously, lightness was being confused with weakness, and speedy erection with short life. Another question indicated the public confusion over the industry's diverse marketing methods, probably more a reflection of the various speculative writings on the subject than of the actual practices themselves. When those interviewed were asked where they would go to buy a prefabricated house, 56.7% said they did not know; 13.7% said the manufacturer; 10.8% said mail-order house or department store; 8.8% said dealer-builder; and 5.2% said lumber yard. Some two years

[103] *Urban Housing Survey,* Curtis Publishing Co. (Philadelphia, 1945).

later, a *Fortune* poll [104] gave much the same results: 70% had heard of prefabricated houses, but only 16% were interested in living in them. Thirty-three per cent said they would buy them only if they could get nothing else, and when this group was asked what it disliked about prefabricated houses, the replies were:

Unsatisfactory construction (included "not substantial enough," "not strong enough," "not permanent," "not warm enough")	67.4%
Lack individuality	13.4%
Too small	4.6%
All other	18.4%
Don't know	9.6%

(Some gave more than one answer.)

Thus, in meeting the need for demountable and temporary houses of the lightest kind of construction, the industry was given an additional handicap to overcome in the way of public prejudice.

[104] *Fortune,* XXXIII (April 1946), 275.

Part I.

Chapter 3

1946–1949

GREAT EXPECTATIONS AND DISAPPOINTMENTS

The preceding chapter outlined the development of prefabrication from early efforts through the war housing program. This chapter is devoted to a description of the industry during the few years since the end of the war. If in the first postwar months the homebuying public and much of the business world were overly enchanted by the promises of prefabrication, they probably have recently been as grossly disenchanted, so that now, in a number of areas at least, the opinion is that prefabrication has been tried and found wanting; that the issue is settled: "prefabrication isn't practical." This chapter might well begin with a protest against too great a disillusionment.

I. Background

A. The Shortage

The background against which prefabrication played its role in the early postwar years included, among other things, a house-hungry public, some significant shifts in political opinion, a major building boom, and, not unrelated, a major inflation. The nation had been hearing about the postwar dream house for four years. On top of a cumulative shortage growing through the thirties and a shortage caused by the cessation of normal building during the war, there were returning veterans and high marriage and birth rates to be reckoned with. It was estimated that as many as 3,000,000 houses would have to be built in 1946 and 1947 just to keep the situation from becoming worse.[1] Furthermore, the great bulk of these homes had to be provided for families in the middle- and lower-income groups. Many looked to prefabrication to meet a major part of this need. It is true that in the public mind there remained a picture of the minimum standards to which prefabricators, through no fault of their own, had had to build during the war. But many also believed that World War II had done for prefabrication what World War I had done for the automobile industry. Dream houses would roll off production lines by the million and somehow end up in suburban

[1] Wilson W. Wyatt, Housing Expediter, *Veterans' Emergency Housing Program; Report to the President* (February 7, 1946), p. 4.

neighborhoods behind rose bushes and white picket fences. A group of startling housing ideas paraded before the eyes of the reading and movie-going public: the Dymaxion house, the Tournalayer, the "solar house." [2] Houses would be built of wood, as in the past, but large numbers would also be built of concrete, steel, aluminum, plastic-impregnated paper, and many completely new materials.

B. The Wyatt Program

In such an atmosphere, Wilson Wyatt was summoned to Washington by the President in January 1946 to become the Housing Expediter. Five weeks later he submitted a program to the President establishing a goal of 2,700,000 housing starts by the end of 1947 and calling for "the same daring, determination, and hard-hitting teamwork" with which the nation had "tackled the emergency job of building the world's most powerful war machine." [3] Private enterprise was to assume the leading role in this task with the aid of extensive federal measures aimed at expanding and directing production. The labor force in residential construction was to be tripled, and local voluntary committees were to be established to help veterans find homes, eliminate building bottlenecks, provide sites, reform building codes, and speed the housing job in general.

Most of Wyatt's legislative proposals were enacted by Congress in May 1946 as the Veterans' Emergency Housing Act.[4] The program which emerged from this legislation set out to increase production by using surplus war plants, by making premium payments to stimulate manufacturers of materials, by guaranteeing markets for new types of materials and prefabricated houses, and by the financing of new enterprises through Reconstruction Finance Corporation loans. It sought to direct materials flow by curbing non-residential construction and establishing a system of priorities, allocations, and restrictions on house size; and to check the strong inflationary tendencies (which had been aggravated by the liberalized FHA-financing pro-

[2] These terms are explained at length later in the book.

[3] Wyatt, *op. cit.*, p. 1.

[4] Public Law 388, 79th Congress, approved May 22, 1946. Wyatt requested as an essential part of his program passage of S. 1592, the Wagner-Ellender-Taft bill. This was a comprehensive long-range legislation providing for increased FHA insurance, public housing, urban redevelopment, and other measures. Congress did not pass this bill, chiefly because of the public housing provisions.

visions of the act itself) by controlling prices of materials and finished houses.

In short, the Housing Expediter and his executive powers with respect to other agencies such as the Office of Price Administration and the Reconstruction Finance Corporation represented an extension of wartime government controls into a postwar period of acute housing shortage. As a part of the overall goal, 250,000 prefabricated houses were to be started in 1946, and 600,000 in 1947. Although this program was under attack from certain quarters even in its earliest phases, there was nonetheless a short period during which it appeared that the kind of cooperation and self-restraint necessary to success would in fact be forthcoming. Committees were organized on the local level, labor leaders pledged full support, and a number of large industrial enterprises were reported to be ready to go into prefabrication: Henry J. Kaiser, Higgins Industries, Inc., Douglas Aircraft Co., Inc., Beech Aircraft Corp., Consolidated Vultee Aircraft Corporation. This lent the program a certain amount of prestige and, together with a favorable press, tended to bolster it against growing criticism from numerous elements in the building industry. But with the return to peacetime activities and interests, public support diminished; broad political attitudes changed; the press and organized criticism cried out against "government intervention"; general price controls were weakened, then abandoned; and the housing program was the next to go. After the November election had placed the Republicans in control of Congress and after Wyatt had run into considerable opposition from a few key men in the Administration,[5] he felt that the program was not going to receive the necessary support, and in early December he resigned as Housing Expediter. Ten days later the President announced the end of most of the controls; premium payments, materials allocations, curbs on non-residential building, and price ceilings were abandoned. The market guarantees and loans to prefabricators, however, were continued until the end of 1947, as specified in the law.

In retrospect, it hardly seems possible to classify the Wyatt program as other than a failure. Perhaps it was doomed from the start as a grandiose and somewhat visionary experiment. Building starts did accelerate in the late summer, but the overall total for the year

[5] Much of the dispute was over Wyatt's inability to secure RFC loans for selected prefabricators. The final breakdown came over his failure to have the Dodge war production plant in Chicago assigned to Lustron Corporation, plus a large RFC loan.

was 776,000 units started, a good bit below the target of 950,000.[6] Furthermore, completions dragged because of shortages in materials and labor. Prefabricators produced a total of 37,200 units in 1946 and 37,400 in 1947[7]—not a bad performance in view of the extent of shortages and unfamiliar restrictions, but far short of the program's ambitious goals. Of these totals only a small fraction can be attributed to the government measures. By the end of 1948 it was reported that of the 32 companies which had secured guaranteed market contracts or loan agreements through the RFC only six were in active production.[8]

On the other hand, it should be pointed out that the program was never really given a chance. By the time the administrative machinery was working, hostility was so great that few if any positive results could have been expected. Whether the reconversion and expansion would have been faster without any government program at all, and would at the same time have provided for medium- and low-cost homes (as critics of the program claimed) is a question that must remain unanswered. Many of the critics spoke from long experience and good common sense. Nevertheless, some of the boldest, most risky, and in the long run perhaps most significant ventures would never have gotten under way without a stimulus from the government along the lines proposed by Wyatt. The lessons learned from one such really industrialized house manufacturer as Lustron, even if it should never reach its production goals, may prove to be worth all the money spent by the government[9] and the temporary doubts cast on prefabrication as a whole. This, too, is a question that remains unanswered.

[6] Both figures are for permanent dwellings, conventional and prefabricated, and do not include conversions and trailers (for which the 1946 target was 250,000).

[7] PHMI *Washington News Letter,* January 30, 1948, p. 3. 1946 total by the Office of the Housing Expediter; 1947 total based on figures estimated by PHMI and submitted to the Bemis Foundation. The 1948 total has been estimated by PHMI at 30,000 and 1949 total at 35,000.

[8] Business Week, 1006 (December 11, 1948), 25.

[9] It was estimated by the Office of the Housing Expediter in June 1948 that the guaranteed market program, at that time almost completely closed and settled, would not result in a loss to the government of over $3,000,000. What losses the RFC will take on the loans it has made, many of which are outstanding, is hard to say.

C. *The Birth and Death of Firms*

Meanwhile the ranks of the prefabricators had swollen rapidly so that, by the end of 1946, 280 companies had received priority ratings from the National Housing Agency—as against less than 100 firms in the industry some two years before. This rapid expansion served to emphasize the ease of entry into the industry, but it was also a reflection of the fact that many so-called prefabricators were nothing more than distributors of building materials who did a minimum of work on the materials they handled in order to secure higher prices under existing regulations. There were others who called themselves prefabricators in order to obtain priorities for certain materials and who hoped to obtain guaranteed market contracts and capital loans to start them on their way with little or no risk capital of their own. Because the established firms feared that their reputations and that of the industry as a whole would be adversely affected by the failures of the newcomers and the poor quality of their products, they sought to protect themselves by adopting quality standards and by attacking the program which had brought about this great influx.

Unfortunately, most of these fears were well founded. High expectations attracted new enterprises, and the new enterprises had a high death rate. Many never got into production at all; many others failed; some retired to more conventional phases of the building pattern. By the end of 1947 the number of active prefabricators was again less than 100, and in the wake of the failures there had grown a profound skepticism regarding all that went by the name of prefabrication—especially in banking circles. This purging of the prefabricators was somewhat reminiscent of early years in the automobile industry, and, if the outcome is as healthy, there may still be cause for optimism.

Among the new enterprises were several of real interest, set up to operate along lines which in one or more aspects represented a greater break with conventional building than was made by the vast majority of prefabricators, and often facing great difficulties as a result. In this group might be included those who worked with aluminum and plastic-paper sandwich materials,[10] with standardized, universally

[10] Southern California Homes, Inc., was the only company in this category to come close to production.

adaptable modular panels,[11] with the sectional house idea,[12] with the "solar house" idea,[13] and perhaps, because the design of the house was approached with the same freshness that has marked the recent interior design of trains, ships, and aircraft, with the hemispherical Fuller house.[14]

D. The Building Boom

All the above activity should be viewed against the general background of a building boom which proceeded with at least customary violence. The number of permanent non-farm dwelling units started with 209,000 in 1945 and went to 670,500 in 1946; to 849,000 in 1947; to 931,300 in 1948.[15] Residential construction costs went from 143.7 in 1945 to 159.2 in 1948 to 193 in 1947 and to 214.7 in 1948 (1939 = 100).[16] The emphasis was primarily on single-family residences for sale, and many families which might have preferred to rent were forced to buy in order to secure any housing at all. A flourishing gray market in building materials imparted to the whole endeavor a bad odor. There were some significantly successful efforts at producing good low-cost housing, chiefly by a few big operative builders who made news because of the efficiency of their large-scale operations, but by and large the housebuilding industry seemed to function much as before—especially in regard to its characteristic of increasing costs with increasing output. With construction activity using the avail-

[11] The idea of selling such panels as building elements to contractors was proposed at first by such companies as The HomeOla Corporation and General Panel of New York, but in both cases was later subordinated to the merchandising of a complete house or houses.

[12] In this country the Reliance house and the Prenco house (produced by Robert F. Johnson & Associates, formerly Prefabrication Engineering Co.) and in Great Britain the AIROH house remain in this category. Reliance is now in production, and Johnson has abandoned stressed skin construction for standard framing, sheathing, and siding in the conventional manner. 54,000 AIROH houses were produced for the British Temporary Housing Program, and an additional 15,000 have been ordered by the government as temporary housing.

[13] Green's Ready-Built, which pushed this idea in 1946 and 1947, is now defunct.

[14] Fuller Houses, Inc., now defunct.

[15] Includes privately and publicly financed units, prefabricated and conventional. Data from *Construction*, U. S. Bureau of Labor Statistics (April 1949), p. 5.

[16] Compiled, from figures of E. H. Boeckh and Associates, by NHA and HHFA, *Housing Statistics* (April 1949), p. 8.

able resources to their limit, building costs were bid up by a flood of purchasing power created by wartime savings, high incomes, and, most of all, by easy mortgage credit. Between the end of 1945 and mid-1948 the mortgage debt on one- to four-family residences had risen about 65%, while non-farm family incomes had increased only about 25% and the number of dwelling units by less than 10%.[17] In 1947 more than half of the mortgage lending was being sponsored by the federal government under legislation enacted by Congress (the Veterans' Administration and Federal Housing Administration programs) and was on a basis that required a very minimum of builder's or buyer's equity,[18] or no equity at all. Factors such as these led the Chairman of the Board of Governors of the Federal Reserve System to describe "excessively easy mortgage credit" as "perhaps the most inflationary single factor in the present [November 1947] situation." [19]

By mid-1948 a change in the situation was apparent. Mortgage lending, especially on small homes, was tightening up. The trend had been indicated for some months, and the expiration in April of the liberal Title VI of the FHA program brought the situation to a head. The re-enactment of a revised Title VI in the Housing Act of 1948,[20] passed at a special session of Congress in August, again made very liberal government-insured credit available only to the lowest-cost houses. A PHMI survey of its membership in the fall found that nearly seven out of 10 placed the financing problem uppermost of all the factors limiting their sales.[21] Prospective homebuyers were having trouble making the higher down payments, and banks were slowing down their lending programs. Other housebuilders reported the same difficulty. The lid was being clamped down. In the short run, building activity might fall off until costs were shaken down, but the very high proportion of the outstanding mortgage debt which had been based on high prices would almost certainly be a serious consideration in the longer-range aspects of economic stability.

It might seem that, in a situation marked by an acute housing shortage and an abundance of purchasing power, sales would present no problem and the prefabricators would have succeeded in selling more than approximately 37,000 houses per year in 1946 and 1947 or 30,000 houses in 1948. These figures represent 6.3% of all the single-

[17] "The Economic Situation at Midyear," *The Economic Reports of the President,* 1949 ed. (New York: Harcourt, Brace, 1949), p. 277.

[18] Marriner S. Eccles, "Inflationary Aspects of Housing Finance," statement before the Joint Committee on the Economic Report, Special Session of Congress, November 25, 1947, *Federal Reserve Bulletin,* No. 33 (December 1947), 1463–5.

[19] *Ibid.,* p. 1463.

[20] Public Law 901, 80th Congress, approved August 10, 1948.

[21] PHMI *Washington News Letter,* October 8, 1948, p. 1.

family dwelling units started in 1946, 5% of the total in 1947, and 3.9% of the total in 1948.[22] But the fact that the market was there was not enough—it had to be reached; the marketing process had to be organized, and for a number of reasons which are outlined later in this chapter this was perhaps the central problem of prefabricators in the period of our study.

II. The Prefabricator: A Stage in Industrialization

The condition of the industry in the early postwar period is summarized in this section by grouping the many different prefabrication operations according to the degree of their industrialization, under headings which represent the major categories into which the industry may be readily divided.

A. The Panelized Wood Frame House

Least industrialized and most typical are those prefabrication enterprises which have brought the production of a standard wood frame structure into a shop where modular panels or room-size panels are fabricated from lumber studs, sheathing of lumber, plywood, or some type of wallboard, and insulation. Exterior and interior wall surface materials are applied in either shop or field with about equal frequency. Such a shop is equipped with jigs, power saws, planers, jointers, and other woodworking machinery, and perhaps some type of machine to simplify nailing. There is a minimum of factory work on ceilings, roofs, and floors, usually amounting to not more than precutting. The house package which is shipped to the site represents somewhat less than half of the cost of the finished house, less lot. Since the design of the structure is quite conventional (see Figure 3), except for its panelization, and since the tools used are very largely the same ones that might be found in the precutting section of

[22] 590,000 single-family dwelling units were started in 1946, 740,200 in 1947 (*Housing Statistics*, Housing and Home Finance Agency [March 1949], p. 2), and 766,600 in 1948 (Bureau of Labor Statistics).

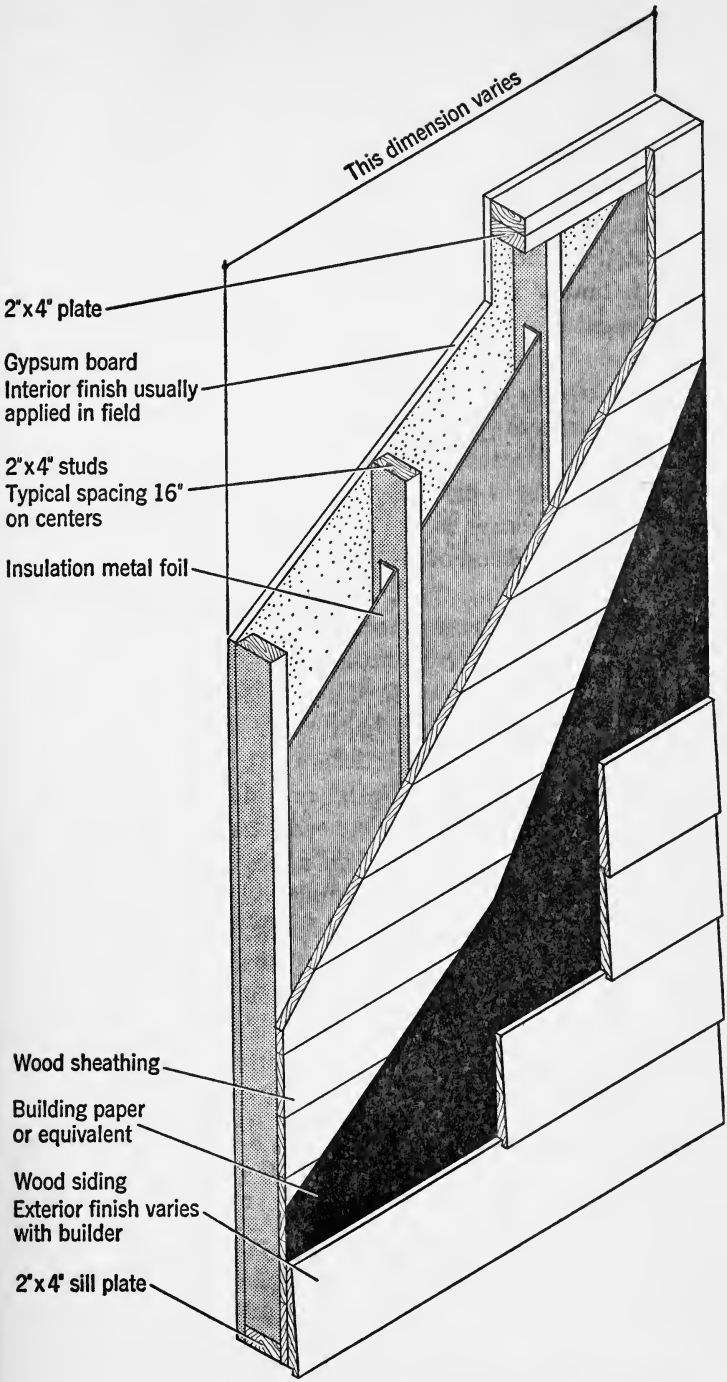


Figure 3. A Typical Wood Frame Panel

a medium or large site-builder's operation, there are few opportunities for cost reduction through saving of materials and greater labor productivity. The principal cost reductions come through working conditions which usually are more convenient, through better division of labor and organization of the work, and through large-scale purchasing. Other potential advantages include better control of materials, more standardized production, better design, and less time and money devoted to site work. Such advantages over on-site construction quite naturally increase as the prefabricator's volume increases or as the size of the site-built project decreases. Against these advantages must be charged the costs of plant overhead, transportation, and marketing, so that when a final accounting is made we find these prefabricators offering a house of about equal or perhaps slightly better quality than the average site-built house at about the same price, any difference in price depending on the number of site-built and prefabricated houses in the projects subject to comparison and the degree to which the marketing and manufacturing processes have been correlated.

While the designs and production techniques of such prefabricators do not represent any significant increases in overall efficiency, they encounter a minimum of resistance in the distribution process. The finished house is generally indistinguishable from the typical site-built house in the lower- and middle-cost brackets. It has one or one and a half stories, a pitched roof, clapboard or shingle exterior, walls of the customary thickness, and other conventional features. Consequently there is little consumer prejudice against it. Furthermore, it is very likely to conform with local building codes. The substantial amount of trade done with local materials dealers and plumbing and electrical contractors helps to avoid another source of resistance.

This is, of course, a gross description and within the group to which it refers there are some wide variations in particular aspects of design, production, or marketing. Yet the characterization applies with reasonable accuracy to at least half of the companies now active.[23]

[23] The figure of 75 active producers was given as an estimate by the Prefabricated Home Manufacturers' Institute for 1948 (PHMI News Release, June 4, 1949). It is very difficult to determine this figure accurately, both because entry into and withdrawal from the industry are relatively easy, and because the line demarcating prefabrication from other manufacturing and building operations is tenuous at best. For 1949, PMHI estimates indicate 85 companies in business, all but three of which used wood for their principal material (PHMI *Washington News Letter*, December 23, 1949, p. 1).

B. The Stressed Skin Plywood House

A greater degree of industrialization is achieved by the group of prefabricators who produce stressed skin plywood panel designs (see Figure 4). They have made several significant breaks with conventional construction practices. Most important probably are the savings in the use of materials made through efficient design and precise engineering. There is also a tendency to use the structural skin surface of plywood as a finish material as well, and to use such composite materials as paper-overlaid plywood and various types of wallboard. Other characteristics are the trend towards prefabricating more of the floor, ceiling, and roof elements, and towards providing a greater degree of prefinish than do the first group. The introduction of certain factory techniques has resulted in some important labor savings. In the factory of such a prefabricator, for instance, we should expect to find many types of woodworking machinery, jigs, and probably conveyer lines. We are apt to find glue spreaders, some type of hot press for gluing, sanding machines, paint sprayers, and drying apparatus.

Unfortunately, the savings in labor and materials achieved by these companies are countered to some extent by the resistance which is frequently met in the local communities. Buyers may be unhappy about the plain flat finish of painted plywood, or about the thin walls, no matter how strong these may be in fact. Many of the prefabricators themselves feel that steps must be taken to conceal all joints, on the theory that buyers dislike joints in their houses. It is not unlikely that the building code will contain some provision that excludes, for instance, the type of wall construction; and since these prefabricators have tended to supply more and more in their house packages, they may run into some form of resistance from local materials suppliers or local labor when they try to obtain certain goods and services needed to complete the house. But while such obstacles are very likely to be encountered in a region in which these prefabricators are, in effect, not known, as in New England, there are large areas where their products have been widely accepted by consumers, building inspectors, bankers, and local building-trades people, notably in the Midwest. In the numerous medium-size cities in this region the houses of these manufacturers are competitive in price with the lowest-cost housing being built and are apt to be somewhat superior in such qualities of construction as structural strength and

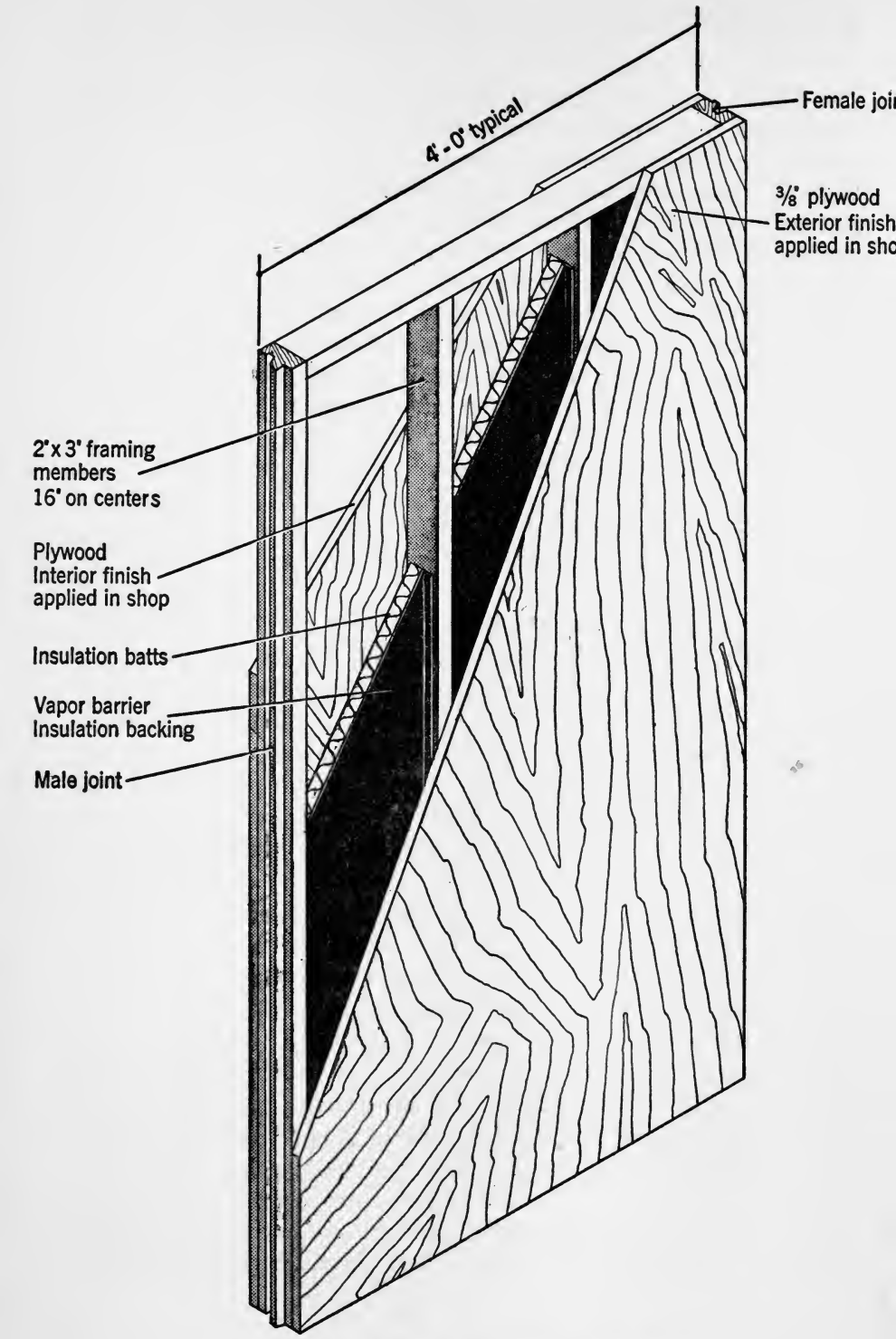


Figure 4. A Typical Stressed Skin Panel

workmanship. They have not yet been markedly lower in price and consequently cannot be said to offer a solution to the problem of providing new housing for families in the low-income brackets, although the industry is now concentrating on reducing costs in every way on special low-income models.

There are perhaps 20 or 25 prefabricators who are producing stressed skin plywood houses, and although this is but slightly more than one-quarter the number of firms in the industry, as a group they have been producing between one-third and one-half the total number of prefabricated houses sold in the last few years. In this group are many, maybe even a majority, of the strongest companies—those who have the best plants and the most extensive marketing organizations, and are potentially most capable of conducting and utilizing technical research.[24]

C. The Machine-Made Metal House

Last are those few firms which represent the most industrialized segment of the field. As a group, if indeed they may be called a group, they are much less homogeneous than are the manufacturers of the two types of houses described above. And as a group they have produced only a small fraction of the total number of prefabricated houses built thus far. Although, as the heading indicates, their common characteristic is that they work principally with metals, by no means all the metal house producers are industrialized enough to belong in this category, and several of the largest firms in it concentrate on farm, industrial, and utility buildings with dwellings as only a minor part of their business.[25]

Because it represented the most completely industrialized of the house manufacturers, the Lustron Corporation may be taken as an example of this part of the industry (see Figure 13). Lustron was long the subject of bitter controversy, not only because of the substantial role of the federal government in financing it and helping it to obtain materials, but also because of its use of porcelain enameled

[24] For example: Crawford, Gunnison, Harnischfeger, Houston Ready-Cut, National Homes, Pease.

[25] For instance: Butler Manufacturing Company, The Steelcraft Manufacturing Company, Stran-Steel (a division of Great Lakes Steel Corporation), and Fenestra (a division of Detroit Steel Products Company).

steel for both interiors and exteriors, and because it was by far the largest and most heavily capitalized prefabrication venture to date. What made this enterprise unique, in the last analysis, was its scale: the extent of its resources in trained personnel, in plant and equipment, and in financial power. If its projected output of 100 houses a day, or 30,000–40,000 a year, could be attained, this would be several times the volume of the largest peacetime builders. The Lustron Corporation invested some $15,000,000 in the types of tools and equipment that have long been employed in a number of mass-production industries but that have remained foreign to housing, such as large shears, presses, punches, welding machines, and enameling ovens. The design, engineering, and sales organizations were conceived on a similar scale. Inasmuch as size (in terms of capital resources) has long been regarded by many observers as the single characteristic most needed in a housebuilding enterprise if it is to overcome the inefficiencies and obstacles besetting the many aspects of the traditional industry, the discontinuity with previous experience which Lustron represented in the matter of scale is of considerable significance. Many have come to regard this venture as a crucial test case for prefabrication, and its receivership will be said to prove the folly of its basic concept. Yet its value as a test case may be limited by the turn in the housing market since plans were made, by the heavy commitment to one material and certain production operations (which restrict freedom of design if changes are to be made), and by the degree of attention which has been focused on the RFC loans made to the company and their possible economic, social, and political implications.

D. Other Types of Prefabrication

Besides these larger groups of prefabricators there are a few working with composite sandwich materials such as Cemesto or aluminum-surfaced paper-plastic honeycomb cores (Southern California Homes) (see Figure 21), with sectional house design (TVA and Reliance), or with certain mechanized on-site processes, usually in connection with concrete (LeTourneau, Ibec, and Vacuum Concrete, Inc.). The manufacturers of cabinets, storagewalls, doors, windows, stairs, chimneys, and kitchen-bath utility cores also belong in the picture of prefabrication as a whole; and making mention of them here will serve to

emphasize the importance of learning to think not how many prefabricated houses are being built, but rather how much of the "average" house is prefabricated.[26]

III. Broad Aspects of Prefabrication

A. Modular Coordination

Although prefabrication is here treated primarily as an industry rather than as a general development, mention should be made of some of the lines along which prefabrication as a broad movement is growing. Modular coordination (see Figure 5) is such a line. At first glance, there may seem only a distant relationship between prefabrication and the effort to coordinate the standard dimensions of all building components so that they apply to any building that is laid out on the 4″ modular basis without cutting or altering at the site. Yet it can be seen that if building materials and components were manufactured in coordinated sizes and with provision for certain standardized joints and constructions, they could be assembled with relative ease and little waste into a wide variety of structures designed along modular principles. Even more important in its long-range consequences, if all dimensions of all buildings were coordinated, many products now independently dimensioned, like kitchen equipment, could be made to fit together, and many major assemblies now rarely mass produced, like staircases, could be produced and marketed in stock sizes in the manner of windows and doors. The reduction of site work and the increase of factory work, involving at least a partial shift of the building process from site to factory, are the inevitable results of a successful program of modular coordination and represent a trend in the direction of greater prefabrication. The modular movement which started with the work of Albert Farwell Bemis in the twenties and gained momentum in the thirties was given added impetus in the war period not only from within the in-

[26] A detailed discussion of the entire industry during this period is contained in Part II.

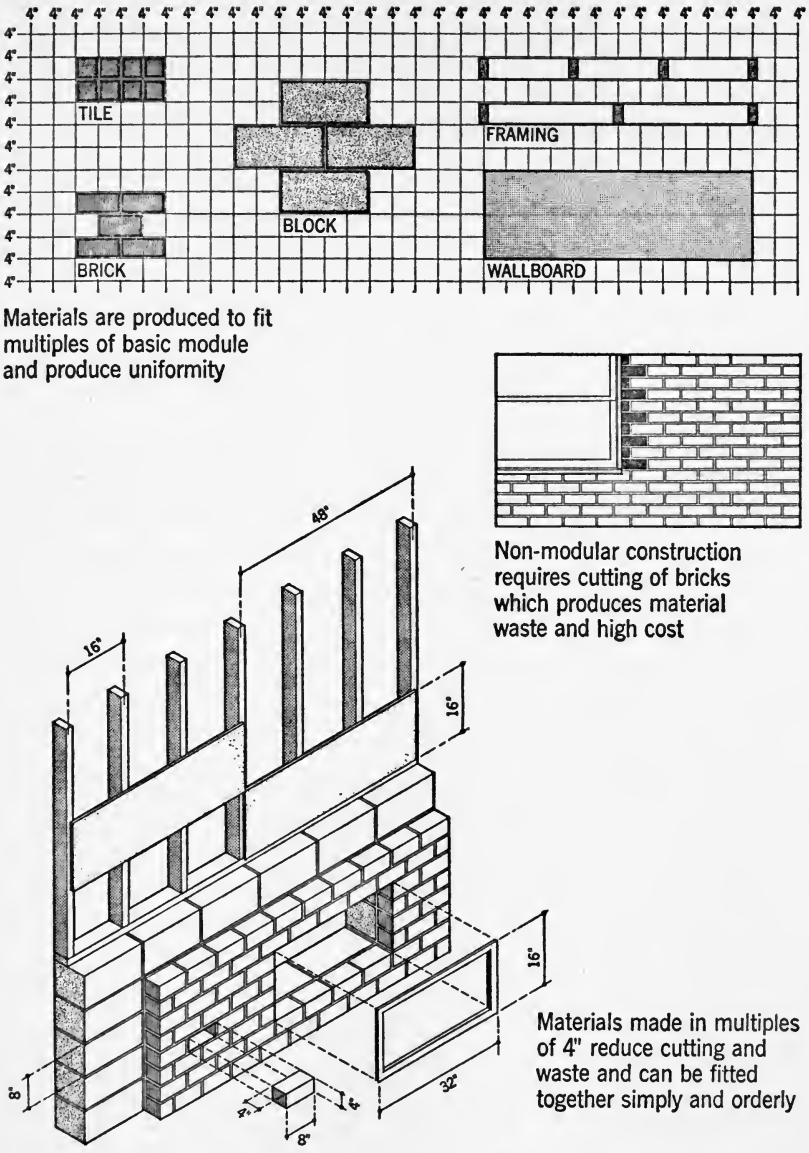


Figure 5. The Principles of Modular Coordination

dustry [27] but from the government as well.[28] Although it has not proceeded as rapidly as it might have, because of the hesitancy of building products manufacturers to incur the expense of changeover in the presence of a seller's market, the movement is an inherently self-accelerating one, and we may reasonably expect increasingly rapid progress as time goes on. Today there are more than 600 firms producing modular structural clay products, masonry, wood windows, steel windows, and glass block, and committees are currently working on the modular design details of other products such as floors, kitchen equipment, toilet partitions, and shower stalls.[29]

B. The Rationalization of On-Site Building

Another effort which has embraced certain aspects of prefabrication is the "industry-engineered house" program sponsored by the National Retail Lumber Dealers Association and The Producers' Council and directed primarily at the builder of fewer than 10 houses per year. The concept of modular coordination is basic to this program in its designs and use of materials. Out of the time studies and cost analysis of the sample houses built by the Small Homes Council of the University of Illinois has come, also, the conclusion that definite savings can be realized through the use of preassembled lightweight roof trusses, making it possible to close in the house quickly with no interior bearing partitions and with unbroken floor and ceiling finish. The flooring, heating, plumbing, and electrical jobs can then be done

[27] Project A62, sponsored jointly by American Standards Association, The American Institute of Architects, and The Producers' Council, Inc., was begun in 1939. It has been carried on with extensive technical assistance from the Modular Service Association, a non-profit agency supported largely by the sons of Albert Farwell Bemis.

[28] During the war, modular coordination methods made a large contribution to the success of the defense housing program, particularly in connection with houses on the design of which Modular Service Association worked closely with the Homasote Co. The Office of Technical Services of the Department of Commerce contracted with the Modular Service Association in 1947 for research and development along these lines. The Housing Act of 1948, Public Law 901, provided the Housing and Home Finance Agency with $300,000 for development and promotion of standardized building codes and standardized dimensions for homebuilding materials and equipment.

[29] "Modular Coordination," *HHFA Technical Bulletin,* no. 3 (March 1948), p. 53.

more efficiently because the interior space is free from any obstructions, and interior partitions can be framed and partly finished while lying flat on the floor, and later tilted up into position.[30] These are perhaps simple methods, and the ideas are certainly not new; yet they are instances of the type of influence that the movement towards prefabrication is having on construction practices at the site. Most big operative builders today not only do extensive precutting but also a considerable degree of near-site shop fabrication of components such as stairs, plumbing stacks, cabinets, storagewall units, and frame assemblies for windows and doors. That some of these techniques have been adopted by small builders as well is only further testimony that the "conventional" builder of today is by no means using the same methods that Noah did on the Ark, despite inferences to the contrary which have had some currency.

IV. Prefabrication: Nature and Cost of the Product

To return now to the prefabricated house itself, it has been widely said that, compared with the lowest-priced conventionally built housing in the community, the prefabricator has been making a slightly better product for about the same money. This is a generalization which is, of course, subject to exception. Certainly low-quality prefabricated houses have been erected in the last few years by the less responsible members of the industry, but on the whole careful control of materials, factory precision of measurement and assembly, and controlled factory working conditions have enabled the prefabricator to meet, if not surpass, the average small-home construction standards. Not all prefabricators are producing for the lowest-price brackets, however; at least one has built houses for as much as $40,000 and others produce in the $15,000–$20,000 range. But by and large most prefabricators have been and are today reaching for the low-income market, which means for the prevailing two-bedroom house a median selling price of roughly $8,000, completely erected and

[30] *Research Report on Construction Methods,* Technical Series E2.1R, Small Homes Council, University of Illinois, in cooperation with Office of Technical Services, Department of Commerce, pp. 32–3.

finished but not including the cost of the lot.[31] Naturally, in the seller's market following the war, selling prices for both prefabricated and conventional houses tended to relate more to what was offered than to costs.

In analyzing costs, however, one must bear in mind that efficiencies of quantity production can be realized in the field as well as in the factory, and it can therefore be quite meaningless to make a comparison between the cost of a single prefabricated house erected on an isolated lot and the cost of a single site-built house in a project of a thousand. So large a project affords opportunities for economies in the procurement of materials and in the work of grading, installing utilities, and laying the foundation, and the builder is able to achieve to some degree the same type of division of labor and consequent specialization that characterize line production in a factory. It is much more meaningful to compare the costs of conventional and prefabricated houses where both have been built singly, whether in small or in large groups. For a one-house project the prefabricated house will typically show some cost advantage, perhaps as much as 10–20%. As the size of the project increases, the cost advantage of the prefabricator is apt to decrease and the nature of the so-called "conventional" construction process will change, the site builder adopting more and more of the techniques used by the prefabricator until, in the very large projects of the operative builder, the prefabricator typically offers no cost advantages. The most efficient housebuilding to date (as measured by cost per square foot) has been done in such large projects. They have embraced varying degrees of prefabrication, some builders doing the work in their own shops near the site, other procuring a house package from a prefabricator's plant as far as 300 miles away. The patterns of these operative builders have almost always been worked out in terms of wood, still our predominant housebuilding material.[32]

[31] Such a figure is approximate, because of geographical variations and differences in standards. For the typical "economy" house of two bedrooms and 768 sq. ft. of floor area, the median sales price among members of PHMI for the completed house, less lot, was estimated as $7,000 in 1949 (PHMI *Washington News Letter*, December 23, 1949, p. 1).

[32] A notable exception recently was the Byrne Organization, Inc.'s Harundale project near Baltimore in 1946–1947, where welded steel frames formed the basis of a structure using other materials such as plaster, stucco, aluminum clapboarding, and asphalt shingles. The expense of setting up near-site facilities to prefabricate structural sections for these houses has been cited as a major cause of the financial troubles which later plagued this project. See *The Architectural Forum*, 90 (April 1949), 143 ff.

V. Prefabrication: Current Problems

That prefabrication has not yet brought about marked reductions in the cost of housing and that it has thus far accounted for but about 5% of postwar house construction have been causes for both discouragement and disillusionment. It is said that, in spite of its promise, prefabrication has not offered any solution to "the housing problem," that it has utterly failed to realize its goals. Although the goals which some have held were unrealistic, it may still be asked why prefabrication has not been more successful in reducing costs and (to the extent that this question is not included in the preceding one) why it has not been more widely adopted. The answers to questions like these should be approached only through an understanding of the problems facing the prefabricator—problems deriving not only from the technical and economic considerations inherent in any comparable industrial process, but also from the complex character of the housing field within which the industry operates.

A. Locus of Operations

Under present conditions, with the majority of prefabricators using wood in a relatively conventional way, the practice in single-house projects is to leave something like half the work (in terms of both man-hours and value added) to be done at the site; in large projects the site work is a much larger part of the total. Whether because wood, used principally, is a material which can be processed with relative ease in the field, or because prefabricated houses have often recently been built in groups, or because engineering advances over conventional construction have not usually been realized, more extensive prefabrication seems simply not to be economically justified.

B. Marketing

Once the house has been designed and the production scheme worked out, there are two vicious circles which frequently confront the prefabricator:

Vicious Circle A. Though the design is superior to current practice, from the point of view both of design and production, "people like what they know" and do not like this design because it is new; the banks consider the house too great a financial risk because of the public reaction; without loans, few houses can be built; and the design remains unknown and unaccepted.

Vicious Circle B. Low volume of production means high unit cost; high unit cost means a small market; a small market means low volume.

These situations are not novel; they occur in many other fields of design and production, though seldom, if ever, in so acute a form. But they serve to place the necessary emphasis on the fact that there can be no mass production without mass marketing. This was pointed out from time to time in the past, and today it is a truism.[33] Yet in the frantic rush of postwar activity, and with materials shortages a major preoccupation, only a few saw marketing as a problem of any magnitude at all, let alone as their chief one. In the midst of a severe housing shortage it was perhaps natural to underestimate the extent of the selling effort required and of the obstacles which would be encountered. The history of the thirties should have provided some lessons in this regard, but it was too easy to ignore these in the light of the war experience and the other problems of the immediate postwar situation. Now, at any rate, this has changed, and the topics of advertising, sales, dealers, and interim and permanent financing are of major concern to most prefabricators.

Most prefabricated houses are currently marketed through the agency of dealer-erectors who combine the functions of selling the house to the consumer, helping him to secure permanent financing, erecting it at the site, and, often, servicing the finished home. There are probably as many as 2,000 dealer-erectors, some being small homebuilders who put up only a half-dozen houses a year, others

[33] A case in point was the statement of the William H. Harman Corporation, in its petition in bankruptcy, November 29, 1948: "We attribute the company's failure to its inability to overcome the complexities of distribution and the difficulties of financing sales and erection."

being large builder-developers who work in terms of large projects. The choice and training of these dealers are of great importance to the prefabricator, for they must be able to supply him with a steady stream of orders on which to base his production, and they must be able to carry out the erection and completion of the house at the site with efficiency and dispatch; otherwise they will add in costs whatever the prefabricator may have managed to save in the shop. The prefabricator must train his dealers not only in the mechanics of the erection process, but also in a whole series of other marketing operations: the approach to homebuyers, building inspectors, lending institutions, and occasionally irate neighbors; an idea of what constitutes good site planning, and some notion of a "reasonable" profit. While a low price is a potent factor in stimulating sales to dealers, it is by no means the only one that must be present. Difficulties presented by codes, building officials, local materials dealers, local labor, banks, and the FHA, plus consumer prejudice, are all problems which must be overcome by patient effort on the part of the prefabricator and his dealers. Bargain prices alone do not solve them. Furthermore, there is nothing that requires the prefabricator's cost savings to be passed on to the ultimate consumer.[34] The high-volume incentive of the manufacturer is not necessarily shared by the dealer-erectors, many of whom operate speculatively and must work hard to assemble land, develop it, and arrange for the many construction operations on each house. In a favorable market, charging what the traffic will bear may look to them like the best policy, and in the inflationary situation following the war there has often been a tendency for them to price the finished house at about the same level as conventionally built houses in the area even if, while still allowing a "reasonable" profit, they might have priced it somewhat lower. Thus it is possible that prefabrication may do better when the market enters a definitely deflationary phase, although other factors then complicate the situation. Just what is a

[34] The same is generally true of the manufacturers of prefabricated building components. For example, the Ingersoll Utility Unit, incorporating kitchen and bathroom equipment and a central mechanical core, cost, when installed, about the same as or slightly more than comparable equipment supplied through the usual channels and assembled at the site. In spite of this, many of the units were sold, partly because procurement was thus simplified, and partly because the plumbing contractors who installed these units could do the job in less than one-third of the time it took by conventional methods and could thus turn over their capital more rapidly, taking a larger number of profits on their sales. Nevertheless, the Ingersoll Utility Unit Division of Borg-Warner suspended operations on June 30, 1949.

"reasonable profit" is of course hard to say, but inasmuch as many dealer-erectors are construction people who have been partially weaned away from conventional practice, they may hold ideas that conflict with the mass-production concepts of the prefabricator. In the long run the prefabricators will have to leave the dealers enough margin for profit to attract the kind of ability that is needed for the job.

A few firms have strong and well-disciplined dealer organizations which erect their houses at a fixed price schedule. These companies have had the wisdom, endurance, and resources to develop extensive dealer outlets and train them well. But sometimes the prefabricator has not developed a good marketing system, or he has relied, as a temporary measure, on a few large projects to carry him along, or both. At first glance this may seem more economical than the investment in time and money which it takes to establish many small dealers whose cumulative efforts supply the plant with a steady stream of orders. It may also seem more economical because certain efficiencies of scale can be achieved at the site. But unless large projects form just a part of a prefabricator's volume, or unless he has, through an extended period, established relations with a number of large project builders who operate steadily, he often finds it difficult if not impossible to keep his plant running efficiently. The big projects materialize slowly; when they do come through, the prefabricator's procurement, production, and traffic departments are placed under a strain to meet high, but temporary, production requirements; and after this there is apt to be a slack period. Such a pattern is more characteristic of a general contractor than of a mass-production enterprise, but, unlike the contractor, the prefabricator has a considerable plant investment and a labor force to worry about. For this reason there is increasing emphasis, especially among those firms which practice a high degree of prefabrication, on developing a distribution system geared to making many small sales rather than a few big ones, thus diversifying sales risk and increasing the prospects for steady-volume operation.

C. Public Acceptance

A special aspect of the marketing problem has been the difficulty sometimes encountered in securing public acceptance. Occasionally there is a real prejudice against prefabrication which is not limited

to a generalized opposition to something new, but leads to action not only by potential homebuyers themselves, but by the community as well, through deed restrictions, pressure on building inspectors, and the like. It stems chiefly from dislike of the minimum-standard prefabricated dwellings built during the war emergency under government contract. The bad reputation acquired in this way persists in spite of the fact that the vast majority of prefabricated houses built since the war compare favorably in every respect with conventional houses in the same price class. Moreover, the very large number of prefabricated houses which have been financed under the FHA have had to pass tests a good deal stiffer than those for most conventional houses. As the public has become aware of this situation its hostility has lessened, and today it is principally the houses of unconventional materials such as steel and aluminum and those of unconventional architectural appearance that are apt to arouse suspicion and opposition, although many communities try to exclude prefabricated houses simply because they are small and inexpensive and therefore likely to give little aid in meeting local tax burdens. In regard to appearance, there has been a strong tendency to make the prefabricated house indistinguishable from the conventional house and to abandon flat roofs and battens.

It is unfortunate that the general trend towards public acceptance is retarded by occasional poor-quality products which act to reinforce latent prejudice. On the other hand, in reaching for the lowest-cost market prefabricators have to make compromises with what the public has come to consider, often wrongly, quality. Many a prefabricator, building sound houses which make use of new construction methods and as a result have light walls of thin cross section, has found it desirable to avoid publicity during the erection process, lest the house be considered flimsy.

D. Building Codes

Building codes have presented a serious obstacle to the growth of prefabrication. One very inhibitory aspect of codes is their diversity. They are so numerous and so non-uniform as to make it difficult if not impossible to standardize certain items for mass production in a factory. Plumbing codes are perhaps the outstanding offenders in this respect and have discouraged a good many prefabricators from attempting to manufacture plumbing assemblies. Another unneces-

sarily restrictive aspect of building codes is that they are generally written in terms of specifications rather than of performance standards, and that the specifications are in many respects outdated. Some codes effectively exclude broad categories of construction, such as dry wall, by indirection. Many exclude new and more efficient structural methods and materials which, from a performance point of view, are perfectly adequate but which fail to meet the code specifications: for instance, code provisions ordinarily require framing dimensions in excess of those necessary or economical in stressed skin plywood construction. There are some even more restrictive code clauses such as those requiring certain types of field inspection, and those providing for preference for local contractors and locally manufactured materials.

An added problem arises from the fact that even an up-to-date, state-wide, minimum-performance code will be of little use to the mass producer if the local communities retain the power freely to impose their own restrictions in excess of those called for by the state code. The prefabricator, who wishes a large market area for a standard product, needs state-wide *maximums* as well as minimums; he needs protection against local code provisions which exceed those required in the public interest. The code problem has received a lot of publicity and a great deal of serious attention in the past few years. Many cities and towns are rewriting their codes; others are adding provisions permitting the testing and subsequent uniform acceptance of new materials and structures; performance standards are to some degree replacing specifications. Groups engaged in work to standardize codes include several building officials conferences, the National Bureau of Standards, and the Housing and Home Finance Agency. Congress recently appropriated special funds for this purpose.[35] But such work moves slowly, and it will require a great amount of time and effort to persuade thousands of local communities to adopt the same overall type of building regulation. In the meantime prefabricators are managing, through the use of trial or experimental houses and the accumulation of legal precedents, to convince towns of the soundness of their structures, and they are making progress in their own right. Some of the companies in the Midwest producing stressed skin designs feel that in their area of distribution the code problem is no longer a matter of major consequence.

[35] The Housing Act of 1948 included funds for research in two fields, modular coordination and building codes.

E. Local Trade and Labor

The prefabricator occasionally encounters opposition from local materials suppliers, contractors, and labor, who see their earnings threatened by the prefabricator whose package represents materials and labor imported from another community. This has led some materials dealers to favor old customers during periods of shortage (which is perhaps only a natural reaction), to decline credit, to insist on tie-in sales, and to press for building-code provisions protecting their interests. Plumbing, heating, and electrical contractors have at times declined to make installations on equipment not furnished by them because in so doing they lost their customary markup. Likewise, labor has from time to time refused to handle prefabricated material, even when made by another local in the same brotherhood. These obstacles have in general been of only minor and sporadic consequence rather than a consistent source of trouble, but they add to the prefabricator's difficulties, and their net effect has been to cause him to eliminate from his package items and work which he might otherwise have included, often at considerable savings.

F. Financing

The aspect of marketing which has given most concern of late is that of financing. After production is under way, the houses must be sold and paid for, whether the sales are made to distributors, to dealers, or direct to customers. Excepting in the case of the last, arrangements must be made for some kind of interim financing. A house package is an expensive item, amounting to between $3,000 and $4,000 in most cases, and few prefabricators are well enough capitalized to extend credit until permanent financing has been arranged on the house by a lending institution. Rather than tie up his capital in this way, the house manufacturer must keep it turning over in order to operate at high volume, and therefore he usually asks the dealer to pay upon delivery of the package. This in turn tends to put a strain on the dealer or to limit his volume, for he is often unable to obtain the credit extended to builders by building materials suppliers and must wait to receive payment from the bank in installments as the house progresses, the first installment not being paid, as a rule, until the house has been shelled in. A further com-

plication is the fact that a prefabricated house is a chattel and does not become real estate until it is erected and attached to the land. It is therefore subject to different laws and requires a somewhat different credit instrument.

The acceptance corporation has been used in other fields to meet this problem, and at least one company has succeeded in setting up one to finance the sales of its prefabricated houses.[36] When a house package is delivered to a dealer, the acceptance corporation pays the prefabricator for it and makes the first of several construction advances to the dealer. The acceptance corporation subsequently sells the mortgage, which represents final or consumer financing, to a savings bank or insurance company. There has been considerable interest in establishing independent companies to handle the problems of a number of prefabricators in this way, combining chattel and real estate mortgage financing, and possibly extending the scheme to cover such items as refrigerators and ranges. To date, however, no such independent company has appeared. The effect of federal insurance of mortgages (FHA and VA) in decreasing the risk and increasing the negotiability of mortgages as earning assets would be very significant in any such development.

One other source of aid in facing interim financing problems has been the extension of FHA insurance operations to cover working capital loans to prefabricators and short-term financing of dealers.[37]

The last financial step is that of the ultimate buyer, usually in seeking a mortgage from a bank. Though the banks have presented no general obstacle, they have in some areas been very conservative and very skeptical about prefabrication. Sometimes this conservatism has made itself felt in the difficulty of obtaining working capital loans; more often it has been exerted in the field of mortgage financing. It is in no small sense true that the prefabricator sells his house to the bank (or other mortgagee) rather than to the home buyer. With present-day mortgages amortized over long periods, usually considerably in excess of the average span of homeownership, it is natural that lending institutions are concerned about resale value. Their opposition to unconventional appearance affects site-built as

[36] National Homes Acceptance Corporation, set up in 1947 by National Homes Corporation with the backing of the American Bank and Trust Company of Chicago, and later operating on RFC loans.

[37] Under Section 609 of the National Housing Act, as amended. Under this section commitments have been made for the insurance of loans to prefabricators with provision for substitution of purchase contracts by the manufacturer, making the principal amount in effect a revolving fund.

well as prefabricated houses, but, reflecting local prejudice, they have sometimes objected to prefabrication as such, refusing to lend on it or taking a mortgage for only a small fraction of the value. The FHA has had a very important influence in encouraging banks to lend on prefabricated houses. FHA standards have long been recognized by the lending institutions, and when the Washington office of the FHA approves a prefabrication system and issues an *Engineering Bulletin* to that effect, there is much more confidence in these houses on the part of the lenders. Inasmuch as 40–50% of the prefabricated houses built in the last few years have been financed under the FHA,[38] it can be seen how important the FHA has been in the general marketing picture.

Because of its almost decisive importance, a number of prefabricators have seen fit to criticize the FHA, chiefly in circumstances where they have had to make concessions in design or have had approval flatly refused. It has been held that FHA standards are too high, that they preclude the possibility of manufacturing a really low-cost house, and that house standards should be lowered to the point where homebuyers could afford them. This criticism seems much less valid than those which have been leveled at various local FHA offices for their conservatism in matters of architectural design and for structural requirements held to be unnecessary. Local offices have at times declined to make commitments on houses approved by the Washington office because of disapproval of such design features as flat roofs and because of entirely local regulations regarding such details as door widths. In some instances, different local regulations were actually conflicting. This has led to suggestions that the Washington office issue *Bulletins* approving the architecture of a house as well as its engineering, thus forcing a certain amount of conformance by local offices and giving the house a chance to be accepted. Recently an assistant FHA commissioner has been appointed with the function of assisting the prefabrication industry by efforts to eliminate regional differences in rulings.

In the last analysis this and similar questions of policy rest on a basic judgment as to just how much risk the FHA should take. Many prefabricators feel that the best long-range likelihood of national financial stability involves taking a certain amount of risk and encouraging innovations to speed the development of better housing.

[38] Estimate from PHMI survey of member companies, in a letter to the Bemis Foundation, December 17, 1948.

VI. Conclusion

In the widest sense, current prefabrication is a growing movement embracing a whole span of activities ranging from modular coordination through the manufacture of various building components to the production of houses themselves.[39] Within this advancing front there is distinguishable a house manufacturing industry which existed in embryonic form through the thirties and is now a struggling, growing infant. This infant industry produced more than 100,000 permanent homes in the three years following the end of the war,[40] a small fraction, perhaps, of the total amount of housing built in this period, but a significant total when one considers the investment it represents. Although the prefabricator has not often been able to produce at lower costs than the big operative builders working in the great metropolitan areas, he has clearly demonstrated his ability to compete with the lowest-cost housing produced in the smaller urban areas where the operations of such large builders cannot be continuously sustained. There has occurred a shaking-down process in which the weakest firms have dropped out and the strongest firms have grown stronger, their staffs expanded, their patterns of operation crystallized. And there is a growing body of laws and institutions which are at least in part a manifestation of the strengthening hand of the prefabricator: the extension of FHA operations, the continuing aid of the government through the HHFA and the RFC, the enjoining of certain malpractices through labor legislation, the movement towards building-code reform, and the work of the Prefabricated Home Manufacturers' Institute and the National Association of Housing Manufacturers.

It has for some decades now been a paradox that the wealthiest, most industrialized nation in the world should have been unable to provide adequate housing for its citizens. Even though the house-building industry has moved to cheaper land and reduced the size of its product, it has not been able to produce for the lower-income

[39] "It has been estimated that about 20 per cent of the cost of the average small conventionally built house can be accounted for in manufactured products such as kitchen cabinets, kitchen and bathroom fixtures, heating plant, and the like, as distinct from such materials as bricks, lumber and nails" (*High Cost of Housing,* Report of the Joint Committee on Housing [Washington, 1948], p. 149).

[40] PHMI *Washington News Letter,* October 1, 1948, p. 1.

groups. Prefabricators have earnestly sought to solve this problem, almost always in terms of the free-standing single-family house, but they have not yet come up with a solution. They have pushed the lower edge of the housing market down a bit, but they have not yet moved it a significant amount. What was in the thirties the problem of the $2,500 house is now that of the $5,000 house; the problem remains essentially unchanged.

One suggested answer to the housing problem has been public housing. Fearing public assumption of what has been a private function, some prefabricators have called themselves "a bulwark against socialized housing." But regardless of political views, it is clear that, to date, prefabricators can at best claim for themselves such a role only in terms of future potential.

1 | *20 years ago*

6 *Hodgson houses*

2 | *at time of survey*

The Herford

HERE is a cleanly designed, substantial and altogether good-looking dwelling. There is not one foot of surplus lumber or timber, and yet the result presented is pleasing and wholesome.

The Herford will accommodate a very large family, there being four bed rooms and bath on the second floor. And the living room and dining room are proportioned to the needs of a large family.

Every feature of this design will be found to come under our plea for "modern, sanitary and attractive" workmen's homes. And every feature is planned at the same time to hold down the cost

The Charleroi Gas Coal Co., the Lincoln Gas Coal Co., and the Roanoke Mills Co. are among the many corporations who have found housing satisfaction by the use of the Herford

The house requires but a 20x24 foot foundation and will take but a 25 foot lot. No expensive embellishments are to be observed. A broad porch with the simple belt running around the middle of the sidewalls relieve what might be extreme plainness.

No lower unit cost per person can be secured than is possible in constructing this house.

Price list attached gives our cost on this house.

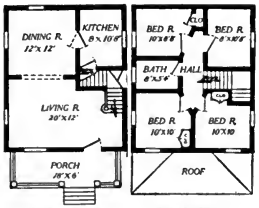
SPECIFICATIONS

THE HERFORD

Size 20x24 Feet

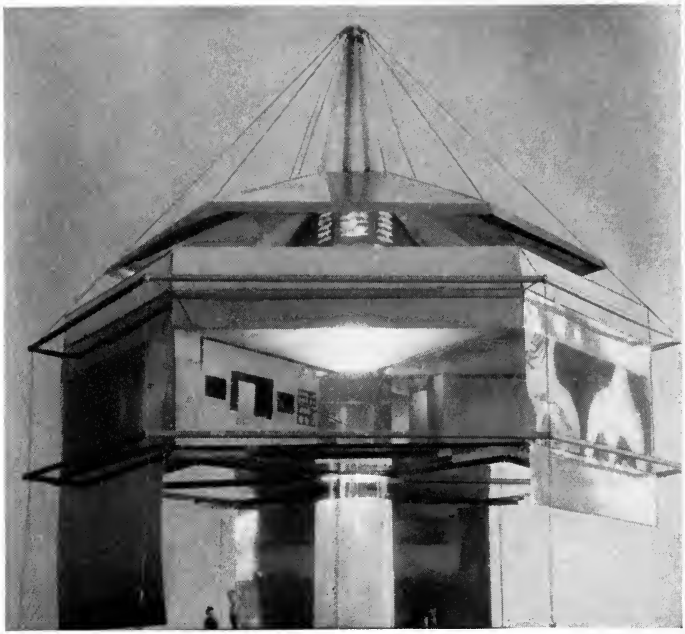
Center sill, 6x8; Joists, 2x8's on 16" centers first floor; Joists, 2x8's on 16" centers second floor; Outside wall studding, 2x4—16" centers; Partition studding, 2x4—16" centers; Ceiling Joists, 2x4—16" centers; Wall sheathing, 1" lumber; Sub-flooring, 1" lumber; Matched flooring clear and knotless; Clear Red Cedar bevel siding or shingles for outside walls; Height of ceilings, 9' 0" first floor, 8' 0" second floor; Rafters, 2x4's on 2' 0" centers, with 2x6 hip rafters; Roof, ¼ pitch; Boxed eaves, 1' 0" projection; Roof sheathing, 1" lumber, overlaid with best prepared roofing or Extra Star-A-Stad Cedar shingles; Windows, check-rail sliding sash, size 26x28 and 26x24, sash glazed; Front door, 2' 8"x6' 8", glazed and mortised for locket; Inside doors and back door, 2' 8"x6' 8", mortised for inside locket; Baseboard, casings, and all interior finish, clear and knotless Oregon Fir or Yellow Pine; All hardware, glass, locks, hinges, galvanized ridge roll, building paper, etc.; Stain and varnish for interior finish; Two coats of paint for exterior, any color desired; Lath and plaster for lining walls, ceilings and partitions

Complete instructions and illustrations for erection



First Floor Plan
The Herford

Second Floor Plan
The Herford



8 *Buckminster Fuller's first Dymaxion house*

1 *under construction*

9 *Early General Houses house*

2 *completed (1933)*

Three prefabricated houses of the 1940's

1 Gunnison

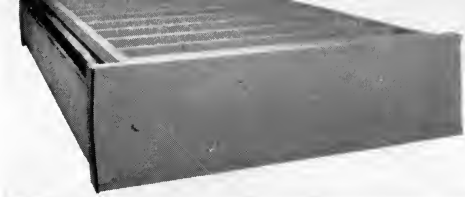
2 National

3 Crawford (under construction)

1 *Fuller's "grain bin" house*

11 *Two circular houses*

2 *Neff Airform House (under construction)*



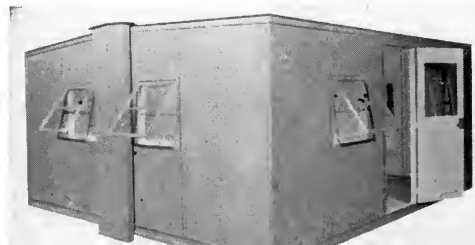
1 basic package

2 half unfolded

3 unfolding roof

4 unfolding walls

12 *A folding unit designed for emergency shelter, the Palace Corporation*

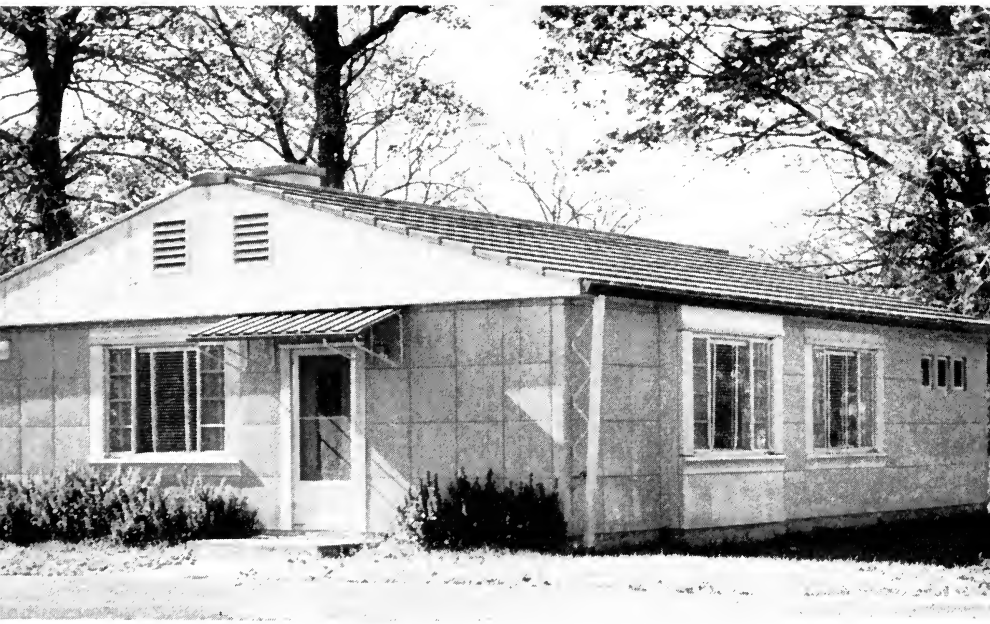


5 completed unit

1 *two-bedroom model, with garage*

13 *Lustron houses*

2 *three-bedroom model*



Part I.

Chapter 4

THE FUTURE OF PREFABRICATION

I. Introduction

This chapter seeks to raise questions and to stimulate thought more than to attempt prophecy. Yet one general forecast should be made at the start, because it underlies much of the discussion which follows. We believe that it will become increasingly difficult to draw a line between prefabricated and conventional construction. At the present time one-fifth of the average house is made up of manufactured products rather than building materials in the ordinary sense. In the future more significance will attach to the degree of prefabrication than to the numbers of prefabricated houses.

This does not mean that the house will become an exclusively site-assembled product; development of the packaged house and the sectional house will doubtless continue. The new processes and procedures which typify many prefabricators seem sure, however, to spread throughout the housing field and the construction industry as a whole, and the benefits of mass production and mass distribution will become generally available. In the end, the prefabrication of houses may well prove to have been only a localized advance, a specialized movement, in this general process of housing industrialization.

II. Current Trends within the Industry

Although many of the broadest problems facing prefabricators have hardly begun to be understood, it is possible to point the probable future direction of trends visible within the industry in its present form. In large part, this discussion is based upon the detailed analysis of the present industry contained in Part II; for that reason, the comments made here may be very general in nature; and also for that reason, the overall order of that Part will be followed.

It has by now become abundantly clear that every step of the prefabricator's operations, from procurement through marketing, exercises an important influence upon every other step. The process used for erection affects the design as much as that used for production; mass sales depend as much upon good financing as upon good design. In the future, therefore, the prefabricators will build up balanced staffs of experts, or will retain consulting services, in order to deal with this whole broad range of problems.

They will also take steps to develop large procurement, production, and marketing units in pursuit of the benefits of size. In the period since the war, more than 30,000 houses have been sold each year, although the number of companies involved has been sharply reduced; this is roughly 30 times as many houses as had been sold per year before the war. In the future, no doubt, there will remain small specialized firms for special types of product or of market, but the lion's share of the manufacturing business will go to fewer and stronger companies. Much of this business will go to companies not producing houses as such at all, but rather producing large components, either of houses or of buildings generally, for assembly either at the site by individual architects, builders, and site developers, or in fairly localized assembly plants.

At the same time, general industrialization of the building industry will be in progress, a very noticeable element of which will be the growth of dimensional coordination. This is a self-accelerating movement, and efforts now being made to educate manufacturers, suppliers, builders, and architects on the one hand, and the consuming public on the other hand, seem certain to bear fruit.

As they grow in size, prefabricators will grow in responsibility and in the desire to maintain a high sales volume over a period of years. Long-range plans and policies and an understanding of the whole housing market will become increasingly important, and a great deal of attention will be paid to the devices of combinations, mergers, and licensing agreements. In the past, there has frequently been speculation on the possibility of the development of a sort of "General Motors" for the production of houses. We have described in earlier chapters a few prior attempts to set this up; when the time seems right, it will be attempted again.

Several of the prefabricators have already managed to integrate their operations to some extent—more often by controlling or actually

owning their suppliers of basic raw materials than by controlling their marketing operations. In the future, this process will continue in both directions, seeking the advantages not only of simplification in management and reduction in cost, but also of the marketing feature of making it possible for the buyer to turn all his problems relating to his house over to a single large organization. By the very nature of the product and its marketing process, however, it seems unlikely that there will ever be a housing "Detroit." The large producers will probably be enough different, one from another, to prefer different production areas, and many advantages may be found to lie in decentralized production.

B. Design

1. Materials

Wood. Since designs are very much a function of materials, the future prospects of the use of different basic materials are of considerable interest. It has been said that the traditional domination of wood as a housebuilding material is being threatened. In the form of lumber, its use in prefabrication can be expected to decline.

Plywood and the related bonded paper ply materials, on the other hand, seem certain for a while to maintain their popularity in the prefabrication industry unless there is a substantial reduction in supply and rise in price. Wood fiber products, already in wide use, will continue to grow in popularity, however, and other products of wood technology will continue their rapid development, some so different from those of the present as to warrant calling them plastic materials. This will almost certainly be the direction in which the industrial use of wood for houses will turn.

Concrete. As for concrete, already an important building material in the form of concrete block, many recent improvements in technology will help to bring it into increased use for houses, but it cannot readily be made the object of mass distribution. Rather it will come into its own in the site fabrication of huge projects, with increased reliance on mechanized, portable, and re-usable forming, pouring, and curing equipment.

Clay Products. Structural clay products have been less widely

used in the building industry because of their increasing site-construction costs and the objections on thermal and acoustic grounds to their use as a single-material wall. They will undoubtedly remain an important element in the design of large site projects, but for further industrialization much will depend upon the success of current research in improving their physical properties and in developing larger and lighter units capable of production with greater precision.

Metals. The metals have a bright future, if there is to be an industrialization of houses in the form of finish as well as of conventional framing. Steel is admirably suited to mass production, and the major problems affecting its use in houses, condensation and corrosion, are approaching satisfactory solution. The increasing production and decreasing costs of aluminum and magnesium make these light metals very promising, and they have good properties for housing purposes.

Plastics. Plastics, in the sense of materials molded under heat and pressure, are already in use for trim and accessories about the house, but because of their relatively high cost and low strength they have thus far proved to be unsatisfactory basic building materials. Their future lies in combination as binders and adhesives with other materials such as wood wastes, wood fibers, wood veneers, paper, vegetable fibers, glass fibers, and the like, or as finish coatings.

It is the development of plastics along these lines which has made possible the rapid development of plywood, and the plastic core materials may in a few years become important building materials.

Wallboards. The trend towards dry-wall construction will continue to spur the development of wallboards and composition boards of various types, such as cement asbestos, fiber, and pulp, especially when these are combined in sandwiches with other materials offering different technical or finish qualities.

2. Large Panels

Related to the use of such new materials as the laminated wood-plastic combinations and the metals is the trend towards large panels, which avoid seam and joint problems by maintaining continuity of surface, and simplify structure through a fusion of skeleton and skin.[1]

[1] For a good discussion of the principle of continuity, see Fitch, *op. cit.*, pp. 183–5.

In this connection, there will be an increasing effort to prefabricate those components of the house which offer large, unbroken surfaces, such as the ceilings, roofs, floors, and partitions, whereas today the major effort is directed at the walls. The inherent merit of frame and curtain wall structures for many purposes and in many materials will assure their continued development also, but the light, continuous, combined-purpose walls will advance more rapidly.

3. Factory Finishing

Along with larger continuous surfaces will come the development of better factory finishing. In the metals this trend can be illustrated by the vitreous enamel finish of Lustron. In the woods it may take a new direction, such as resin impregnation or compression or both. Albert G. H. Dietz points out [2] that the assembly of a frame and the application of boarding offer much less opportunity for savings in construction labor and time than do the finishing of floors, the painting of woodwork, and the many other finishing details; and that significant future advances may come from the use of impregnation, compression, and high-frequency techniques to achieve the same purposes.

4. Color and Texture

Of greater importance to most people than is generally recognized are questions of color and texture, and here rapid developments seem sure to take place. What the public considers high in quality is often high only in finish quality, and manufacturing processes can produce economical finishes of better performance and of greater variety in color and texture than those now used in the housing field. At present there is some experimentation with color, but the possibilities of texture have gone almost unnoticed. It seems to be generally assumed that people like uniform flat surfaces on their walls, and to be further assumed by such companies as Lustron that they like uniform color and washable finishes as well. Yet little is actually known about the merits of different textures and finishes because in

[2] "Progress in Wood Construction," *Wood Preserving News*, XXV (December 1947), 110 ff.

the past relatively few possibilities have been available for use in the house.

It should prove to be desirable to produce surface finishes which do not require constant cleaning, no matter how easily they can be cleaned. Certainly this seems to have been the conclusion of the makers of linoleum. A little texture—a fine corrugation or processed pattern—together with an irregular color pattern might make it possible to clean less often, and in addition add improved mechanical and acoustical performance. Less uniformity should mean easier production control, and corrugation or stamping should permit the use of lighter gauges of metal. These possibilities are certain to be explored in the future.

5. New Structural Forms

With the new materials and a higher degree of factory finishing will come new structural systems and new plastic forms for the finished house. Although in the mind of the typical homeowner the house may be essentially rectilinear, there is plenty of historical precedent for other forms where the structural basis is other than post and lintel. At present, consumer resistance to the Fuller or Neff hemispherical houses would be violent but perhaps less widespread than has been supposed. In one known instance, the majority of a group of potential homeowners wanted to examine a hemispherical house before making up their minds, although they had summarily rejected a contemporary rectilinear design in favor of a traditional design. An entirely new form may have a better chance for acceptance than one close enough to a traditional stereotype to cause constant irritation because of its differences.

Revolutionary designers tend to feel that the logic of structural efficiency has an overwhelming appeal. There seems little reason to believe, however, that we demand a high degree of structural efficiency in the house. Architectural design involves many problems; and, in the future, basic considerations of plan will continue to dictate the structure, rather than the reverse.

Indeed, the structure of the house is a mystery to the average person, and he rarely even shows an interest in it. This was illustrated when a new type of steel construction was used in an exhibition house put up in 1933 at the Century of Progress exposition in Chicago. Pleased with their achievement, the engineers responsible for

the design put glass insets in the walls to show construction features and handed out questionnaires to find which aspects of the house had most interested their visitors. Far above all else in terms of popular interest was the presence of twin beds, and in second place by an equally commanding margin was the use of venetian blinds. The construction was hardly mentioned. Clearly, the public expects professionals and trained officials to watch out for its interests in these matters.

6. Project "Variety"

The industry will gradually grow away from the tendency to seek "variety" through the application of exterior materials, details, and finish treatments to identical houses in the hope of giving the appearance of that random collection of structures which has characterized our neighborhoods in the past. The results obtained by these devices are rarely pleasant, and often they achieve only what William W. Wurster has called "the monotony of slight variation." More important in the future will be variation in color, in placement of houses, in arrangement of the lot and street lines, and in relationships established with garages and other structures—a variation which obtains its quality from a frank recognition of the basic similarity of the houses involved.

It will be recognized that, beyond a certain size (the definition of which requires study), a project of similar houses develops an oppressive monotony which no artistry can dispel. Those living in such projects know this, if the builders do not, because the reasons lie as much in the formation of an oversized mass of similar family groups as in the architectural effects.

7. Mechanical Cores

The mechanical services and equipment of the house represent from about a third to as much as half of its production cost. It is certain that the effort to design these as a unit core and to mass-produce such units in ever larger components will continue. In the next few years development here may come even more rapidly than in rationalization of the rest of the structure. The difficulties now faced

by the makers of mechanical cores are certain to diminish, for improvements along this line offer great cost savings, production and erection simplifications, and sales and service advantages. One can easily foresee the development of a mechanical core together with a basic structural frame capable of carrying the weight of framing and finishing the entire roof as well as a curtain of walls and windows; and undoubtedly there will be special models of cores available to provide different standards of service.

8. Integrated House

There will be developing at the same time the integrated house, manufactured for sale as a single unit offering little or no design variation, and incorporating all its mechanical apparatus. While this may seem a logical extension of the mechanical core, it is in many respects a quite different development, for it requires that the entire house be dealt with as a unit, while mechanical cores may be used in connection with "conventional" buildings or even existing buildings, as well as with prefabricated houses.

C. Procurement

1. Materials

The obvious procurement problem is that of future supplies of basic raw materials. For wood the situation at present is very different from that of a few decades ago. Our forests have very rapidly diminished, and although wood is the only one of the major raw materials of building which can be replaced as a crop, not enough concerted effort in that direction has yet been made in this country. Yet for wood, and for plywood, it cannot be said that there is any immediate prospect of a shortage.

Furthermore, there are new processes in operation and under development, making use of smaller pieces of wood in edge-grain plywood and employing special surface materials which permit the use of smaller quantities and poorer grades of veneer. Illustrative of the materials made by these processes are paper-overlaid plywood

(resin-impregnated paper bonded to rough plywood to give a smooth hard surface), K-veneer (heavy kraft paper bonded to a single thick veneer which has been slit and distended before bonding to increase dimensional stability), and several types of wood core with bonded metal surface.

There seem to be few procurement problems for the concretes and clay products, and the story of the metals is widely known. The supply of steel is a matter more of national policy than of the availability of basic raw materials, although there may be significant changes in the production centers and distribution systems in the future with the development of new sources of ore and changing price policies. As in the past, any defense emergency will mean the pre-emption of steel supplies for war purposes, and the housing industry will be forced to use substitutes to the fullest degree possible.

This is also true for the light metals, for which the future in terms of raw materials and increasing production capacity looks very bright. For both aluminum and magnesium, it is not the supply of raw material so much as the cost of power which determines available supply. Production of both metals increased greatly during the war and is likely to increase again in the future. It has been estimated that the aluminum used today in such elements as windows, insulation, roofing, and spandrels for the building industry is greater in total amount than the prewar production for all purposes combined.[3]

2. Components

Where prefabrication amounts to little more than the assembly of components fabricated by others, procurement obviously becomes the heart of the operation, but many feel that one of the most important contributions of even the typical prefabricator has been the streamlining of building supplies and equipment distribution. This function will expand in the future as supplies and equipment manufacturers satisfy themselves of the reliability of the prefabricator as a source of large and steady orders, and as further vertical integration occurs within the prefabrication organizations themselves. Eventually, more and more prefabricators will strive for the position common in the automobile industry, in which the company is large enough to control its suppliers.

[3] Howard T. Fisher, "Prefabrication; What Does it Mean to the Architect?" *Journal of The American Institute of Architects,* X (November 1948), 220.

1. New Processes

It is not possible to give general consideration here to the future of industrial techniques in prefabrication industries. Processes which are likely to show an increasing development in the next few years may be listed, however. For wood, they include gluing instead of nailing (a manifestation of the tendency towards more continuous surfaces), high-frequency induction heating for the curing of glues, and thermopressure molding of plywoods. For steel and for the light metals it seems certain that there will be more common use of factory finishes, such as vitreous enameling or some of the other forms of baked finishes at present used for automobiles. The cellular and corrugated core materials will leap into prominence with the development of any method of continuous strip production of the cores, but this is not an easy problem.

2. Production versus Erection Economies

In the past, a great deal more energy in the design of the prefabricated house has been devoted to securing economies in the factory than in the field, and often the result has been that unexpected field costs have overbalanced the factory savings which were so carefully planned. This will be discussed in more detail under Erection (p. 111), but it should be pointed out here that this lesson is being learned, and that production schemes in the future will take into account the efficiency of the operation as a whole.

3. Standardization versus Specialization

In any production scheme, attention must be devoted to the question of standardization. It is often said that parts should be standardized and made interchangeable to the fullest degree possible, but this depends very greatly upon the expected rate of production and the variation in production models. If a single product is to be fabri-

cated in large quantity, there may be savings in designing specialized parts for maximum efficiency without full standardization. To standardize could be to make certain parts unnecessarily strong and thus wasteful in materials. On the other hand, when parts are standardized as fully as possible, there may be greater simplicity in procurement, production, packaging, and erection. The prefabrication organizations of the future will be better able to determine accurate costs and to decide these production problems on a realistic basis.

4. Operational Decisions

Production operations themselves will receive considerable study: the breakdown of the job into simple and repetitive operations, the use of a continuous-flow production line to pace production, and the use of jigs, of work-simplification and production-control techniques, and of sound accounting procedures.

Many of the most important production decisions will depend upon the expected market. Analysis of the market in some cases will call for the decision to stay with wood construction and repetitive station operation, in order to permit considerable variation in rate of production without undue plant costs. Once the choice of steel is made, however, a production line seems indicated, and a mass-marketing mechanism at a high level of stability is required. No mechanism has yet reached this high level, but attempts will be continued in the future.

In any case, it seems certain that the prefabricators will be among the first to make available to the mass-housing market the new materials and methods of construction, and many of the new items of special service and appeal, in so far as these are well adapted to factory production methods.[4] As other builders fall in line with public demand for this development, the fabrication of an ever-growing portion of the house will be transferred to the factory, until eventually the operations of the entire housing industry will become so advanced that little significance will remain in a distinction between the prefabricators and the other producers of housing and building components.

[4] Factory construction itself has long been a proving ground for new design ideas. See Fitch, *op. cit.*, pp. 68–9.

E. Marketing

Throughout this book, emphasis has been placed upon the importance to prefabricators of building sound marketing organizations, partly because mass marketing is always a prerequisite to mass production, but largely because uniquely difficult marketing problems are presented by houses. Considered simply as physical products, they involve great difficulties of assembly, packaging, transportation, and, in most cases, erection, and the design and production processes are intimately concerned with the schemes developed for overcoming these difficulties. Briefly highlighted here will be a number of special aspects of this general problem, to which prefabricators will give increased attention in the future.

1. Packing

Prefabricated houses are generally transported by means of tractor-trailer trucks, the trailer units sometimes being used also as movable parts of the assembly line. In other instances components are palletized for easy handling, and in still others loading from component bins is worked out as required by each order. In the future, if the design emphasizes many standardized parts, there may follow a development of shipping containers for these parts which will themselves become a part of the final house; and, a small but important point, factory packing and loading will be designed for easy off-loading at the site, where usually there will not be available the specialized equipment common at the factory.

2. Transportation

Generally it will not be possible to transport completed houses, and that fact in itself offers a possibility for variety in the finished house. Sectional houses made up in units of size suitable for shipment in trailers or railroad cars may be varied and combined in different ways at the site to produce houses which are substantially different one from another, and not merely slight external variations. On the other hand, collapsing and folding houses are already well

known and may develop rapidly in the future. Especially when they are made of the new materials with large continuous surfaces and of lightweight construction, they offer a very good solution for the problems of assembly, packaging, transporting, off-loading, and erection. They also have the advantage of immediate roofing-in at the site, which provides protection against the weather and permits the prompt departure and re-use of the trailers. They do not ease the problems of trailer size, of road loading and bulk, or of access to the site, however, and in some cases these will offer serious difficulties.

3. Erection

In theory one of the great savings of prefabrication lies in simple, expert erection handled by trained dealer organizations. In fact, of course, such trained organizations have been the exception rather than the rule because of the rapid growth of the industry and because a new type of man is required in the dealer role. The old-time lumber yards and the conventional builders in many cases appear to be unable to reach full speed or efficiency in handling these new responsibilities. As a result, many a prefabricator is taking steps to create his own dealers by training young college graduates in his plant and later sending them out in the field and financing them until they get on their own feet. The establishment of expert dealer organizations will take time. As they come into existence, however, they will bring about cost savings very rarely achieved up to now.

It should be added on the subject of erection that the small standardized parts, or components, which have so many advantages elsewhere in a pattern of operations, tend to be at a disadvantage when it comes to assembling them at the site, often in positions awkward for manual labor, and to sealing the numerous joints that necessarily are involved. The prefabricator of the future will be wary of the use of such parts, particularly if they require extra strength or extra labor to make them easier to handle at the site. On the other hand, the smaller parts used in the erection process, such as bolts, screws, and the like, will become as fully interchangeable as possible so that time need not be wasted finding the right piece or trying to make the wrong piece fit.

4. Regional Distributors

At present, few prefabricators make use of distributors in their distribution channels, but the likelihood is that more will do so in the future. When mass-production quantities reach into many thousands per year, it may well prove more efficient to divide the sales area into several regions, preferably having common conditions of climate and local design preference, and to ship the houses by efficient railroad or comparable mass transportation to distribution points in these regions. It will not make sense to send 10 or 20 trucks per day over the same basic route for hundreds of miles from the factory before branching off to the local destination. Furthermore, regional distributors offer a partial compromise on the issue of factory versus site assembly. Site assembly usually means difficult and inefficient conditions. Factory assembly, on the other hand, usually is a space and overhead consumer, particularly when delay in the sales or shipment process requires stockpiling on factory floor space. For a high-production factory, if knocked-down packages were shipped to regional distributors somewhat in advance of normal sales, these men might perform a minimum of preassembly, and if orders were slow, continue with the preassembly process as far as possible within the limitations of the final means of transportation. At the same time, they might be responsible for carrying out regional variations in the basic house, along certain standardized lines. In cold climates they might install more wall and fewer window units, extra insulation, and larger heating systems. If regional construction requirements varied significantly from nation-wide standards, certain standard substitutions could be made at this point, for example in the plumbing.

5. Simplified Selling

One of the great advantages which the prefabricator can offer is the simplification of the various steps through which the individual purchaser must go in order to buy a house. This should start with the establishment of a fixed price. In the future, prefabricators will not continue to allow dealers to establish prices in their own locale. The stronger firms already have their dealers quoting prices from a fixed schedule under their control, and those firms will do best in the leaner days ahead which can advertise the price of a house (less freight and lot) on a regional or national basis. Further

than this, they will have cut down to a minimum the paper work and costs involved in selling, so that title search fee, insurance, amortization, interest, possibly taxes, and even maintenance payments are all included in the only two figures which the homebuyer will have to consider: down payment and monthly payment.

It may also be expected that the dealer, if he is to maintain a high sales level, will increasingly become a guarantor of performance of the product and an expert service man. One-year guarantees are already given in many cases. This will become almost universal, as will a high level of servicing of all sorts, possibly as part of the purchase price.

6. Simplified Financing

Unquestionably the emergence of well-advertised brand-name houses, in combination with a continued or expanded program of government mortgage insurance, will tend to turn the mortgage into a more negotiable form of earning asset. This will fit in with the growing tendency for families to purchase houses out of current income rather than savings. It is possible that the trend will be in the direction of forms of tenure and home financing which combine ownership and tenancy in some manner, as, for example, the purchase-option plan. Prefabricators may be the first to introduce such a scheme on a wide basis.

The nature of interim financing (short-term or construction financing) may be expected to alter as the house is increasingly industrialized. A common future procedure will be the combination of chattel and real estate mortgage financing in which a finance company will pay the prefabricator for his package at the time of shipment, advance funds to the dealer for site improvement and erection and completion of the house, and sell the final mortgage to portfolio investors.[5] In this way the final mortgage lending institution does not enter the picture until the completion and sale of the house, and interim financing is secured less and less by the house itself and more and more by the general assets of the growing prefabrication enterprise.

[5] This scheme was suggested to PHMI by John Richardson in 1948.

7. Sales Cost

Regarding the sales aspects of marketing, there is bound to be a growing realization of the importance of effective advertising and sound sales techniques—involving greater expenditures than are generally allowed for at the present time. The industry has been reminded that it pays for advertising on the average only about $1 per $7,000 house as compared with the automobile manufacturer's average expenditure of about $10–$15 per $1,500–$2,500 automobile. Yet insufficient allowance for the cost of selling at the producer's level has been the admitted cause for failure of more than one promising company.

8. Sales to the Government

As the participation of government in housing increases there will also be increasing opportunities for group sales to agencies of the government, and special attention will have to be paid to this sort of business since it is inherently different from regular private business and has rules of its own. Among these is an old maxim: in selling to the public, sales costs count; in selling to the government, production costs count.

9. Sales to Operative Builders

Sales to large operative builders whose projects are generally identified only with their own names may become an important part of the total prefabrication business, and a few companies may continue to make this a basis of their pattern of operations, contenting themselves to carry on a sort of anonymous refining stage in the housebuilding process and organizing their plant facilities for a fluctuating volume of production. Nevertheless, such sales will tend in the future to be more interesting to the manufacturer of house components than to the prefabricator of finished or nearly finished houses. For in addition to causing uneven production, the large orders of operative builders usually involve little chance for disclosure of the manufacturer or trade name to the final purchaser, and great pressure for variation in the product in view of the size of the order.

The manufacturer finds it hard to build up in this way the all-out mass advertising, sales, and distribution required for mass production. Further, the operative builder, with little fixed investment compared to the prefabricator, can remain inactive when things are bad, and return to compete independently (as he has in the last few years) during a seller's market. This indicates a potential advantage to the manufacturer of components which the manufacturer of trade-name houses will seek to overcome by working with site developers who find value in his trade name, by building up his own site-development teams, and, at the same time, by diversifying his sales as fully as possible. Such men feel strongly that, even from the point of view of a potential investor, the surest protection lies in the diversification of risk and in carrying the advertising and trade-name relationship right through to the ultimate purchaser, as has always been done in other mass-production industries.

10. Market Analysis

The attempt of prefabricators to get a sound market analysis is complicated by the nature of the housing market in general. There is a growing realization of the fact, pointed out by William K. Wittausch,[6] that competition between prefabricated and conventional houses is overshadowed by competition between any kind of new house and the supply of existing houses. As times become bad, the owner of an old house can sell it at less than the *production* price of a new one; and, generally speaking, an old house in a good location will sell better than a new one in a poor location, particularly if the new one is also very small. There is no assurance that there will continue indefinitely in the future to be a ready market for the mass-produced minimum standard house; some signs indicate that the stable market in the future may be rather for houses featuring good value at low rather than minimum cost. The private industrialist will come to recognize that the purchaser of even the lowest-price mass-produced house is in all probability making the largest single purchase of his lifetime, and he will not be tempted solely because a house is in fact and in advertising claim a stripped-down, rock-bottom minimum.

[6] "Marketing Prefabricated Houses," *Harvard Business Review*, XXVI (November 1948), 696.

11. Seasonality

Another aspect of the housing market which bears attention is its seasonal variation. Many a prefabricator seems to assume that this will be eliminated when the production operations are handled in the factory and the remaining local work is efficiently scheduled in advance. It should not be forgotten, however, that seasonality in the housing market is in large measure a reflection of seasonal forces in the lives of the families concerned. School terms, spring cleanings, June weddings, and summer vacations will continue to be important factors after production and erection have been put on a twelve-month basis. Although it doubtless can be reduced, seasonal variation may never be eliminated; in all probability it will continue to have an influence on costs and prices.

12. The Special Nature of a House

The largest marketing problem is found in the fact that houses are not mere consumer goods, to be used and thrown away when they fall apart. They are the focus of the basic social unit in our society and a natural locus for complex social drives and taboos, for unreasoned preferences and idiosyncrasies. Prefabricators are finding that it requires far more skill to mass-produce and market than is generally recognized. This is not understood, certainly, by most of those who would have us believe that the housing industry is completely out-dated and ridiculous. Something like a ball-point pen or a television set, designed to satisfy a relatively new, specialized, and uncomplicated demand, may be manufactured on a fairly logical basis and sold with relative simplicity; prefabricators deal with a real problem in marketing the family home.

III. Future Problems within the Industry

The major future problems arising out of the industry as we know it today include few that are new or unexpected. Yet their very sim-

plicity and obviousness have tended to make them easy to forget, and for that reason they are briefly summarized here.

A. Central or Branch Plants

Prefabricators will frequently have to decide whether to expand central plants or open branches. For houses manufactured of relatively conventional materials, the problem may be solved indirectly, as a result of combinations and integrations which bring a number of separate plants into one large procurement, production, and marketing combination, with production or assembly remaining localized. For the metal houses, a large central plant may be more logical, although component parts could be made by a number of large manufacturing plants and assembled at localized assembly plants; both types of operation have been attempted and so far the choice between them is not clear. The temptation to set up a large, efficient-looking, central production plant will be strong, and such a plant will have no small value as a device for giving both the public and financial circles a tangible spectacle of efficiency, large assets, and stability. For houses of concrete and comparable bulk materials, there seems little likelihood of the development of centralized production or even assembly plants, excepting for specialized components or in areas of unusual concentration of demand. More likely will be the continued development of mobile or portable production machinery and equipment, designed to be set up at the site and to effect great economies when a large number of similar units can be produced within a short radius of operations. Such equipment is particularly suited to the construction at one time of an entirely new project or community under a single developer.

B. Site or Factory Fabrication

It is sometimes argued that good site fabrication makes prefabrication unnecessary, and certainly site preparation and fabrication techniques will develop hand in hand with production techniques generally and will help to effect a general reduction in costs. As the prefabrication plants become increasingly efficient, and as substan-

tial cost savings in the house package become available, however, it is reasonable to believe that even the site developers will find it advantageous to purchase many of their units from the prefabricators. Site developers may also turn to the prefabricators because of the advantages of shifting to them the worries about procurement and delivery and because of the possibility of cutting thereby the time and expense required for construction and financing. At the same time, as we have seen above, the dealers in prefabricated houses will become more interested in large site development. The problem thus becomes not one of choice, but one of taking fullest advantage of both fabrication methods.

C. Low Price or High Value

Although low-cost houses will necessarily continue to be the major market for prefabricators, the industry generally will be faced with the problem of deciding when the time has come to seek better values, by adding space, equipment, or facilities, instead of lower prices. For houses purchased with government aid, there seems every reason to believe that space standards will be moved up from the minima which have prevailed during the last few years; and when the house is privately purchased, owners may become increasingly conscious of the illusory quality of a bargain purchase which proves to be unsatisfactory for normal family living. Space can be added more easily and cheaply than many other features of a house, and, as its great value is understood, it will be increasingly demanded in the future. At the present time, however, space in the house is very hard to merchandise.

The manufacturers who are most interested in better values are those who have found that they can market their product more easily if it contains certain special features or pieces of equipment which on the normal market might come under the heading of luxuries. Mass-produced as parts of the house, such special features probably add little to the cost but a great deal to the salability. Obviously, this can be overdone. The ingenious prefabricator will be careful to develop and include just what is necessary to give his house a special appeal at the best price possible. For a while this kind of gadgetry may have the effect of reducing the real quality of the house in the interest of including more sales features. There is reason to believe, however, that competition within a highly indus-

trialized housing industry and the examples set by the government in its programs for the lower-income groups, together with a growth in the store of general knowledge regarding basic physiological and psychological requirements, will counteract that tendency.

D. Evolution or Revolution

Of the general problems troubling those interested in prefabrication, one of the most interesting is the problem of evolution versus revolution. Evolution is a normal, familiar process, and many argue that it alone can succeed. The argument for revolution may be summarized as follows: factory methods do not promise a reduction in wood-processing costs sufficient to offset the increases in overhead expense which result from moving the operations from the site to the factory; therefore there is little hope of developing a genuinely low-cost home through evolution along conventional lines, and hope must be placed in revolutionary production techniques, probably making use of metal as a basic material.

Against this must be weighed the difficulties of creating an entirely new production process and the necessary accompanying marketing process.[7] It is generally easier to create an entirely new industrial operation to produce new articles, whereas for the mere improvement of old articles, the obvious pattern is a development of old industries. The house-trailer industry in this country sprang up to produce a new article, which offered a service not fully performed by any existing product (although it could also be used as a house when fixed in place); despite its very limited probable market, the industry grew up very rapidly, and recently has been selling more than twice as many units as the prefabricated housing industry.[8] Perhaps this is a trend towards a new way of living and a step in the revolutionary process. Where the attempt has been made to set up an entirely new industrial organization to produce houses in the past, money has always run short before competition with the existing

[7] John Ely Burchard has presented a good discussion of this point in "Prefabricated Housing and Its Marketing Problems," *The American Marketing Journal*, II (July 1935), 150–6.

[8] In 1945 the trailer industry produced 16,225 units; in 1946 it shipped 47,103; and in 1947, 70,078; with a further increase in 1948. Figures from *Facts for Industry*, Series M45A-68, U. S. Department of Commerce (October 11, 1948), Table 1.

industry could be effective. "The sun's rays of capital have been applied often intensely but never for long because no one could afford a sustained effort." [9] Furthermore, there are technical difficulties to be overcome in producing a house equally suited to climatic conditions in Minnesota and in California, and careful design is required if the product is to be both mass produced and non-uniform. And those operating at tremendous scale from the start have little basis in practical experience for finding a realistic compromise between a highly functional product which might not sell well because it is unpopular and a more conventional product which might not show enough saving in cost.

The likelihood is that the natural process of evolution and the earnest attempts at revolution will both continue in the future, and that what might seem in prospect to be revolutionary will seem in retrospect to have been merely evolutionary.

E. One Model or Many

Another problem arises in deciding whether to produce a single, or at the most a very few, standard models offering the best plans possible for average buyers and a consequent efficiency in both production and marketing, or to make a line of component parts which may be assembled to suit individual tastes to a much greater degree. There may also be intermediate stages between these extremes; for example, a company selling a line of many models which are assembled by varying the numbers and arrangement of a relatively few standardized partial assemblies or components. A certain amount of variety in the product is compatible with mass production, as can be illustrated by the automobile industry, particularly by the recent lines of automobiles in which standard component assemblies may be interchanged not only in different models of a single make but even in different makes of cars, from the smallest to the largest. Furthermore, we have seen that it is possible within the requirements of mass production to make allowance for a certain degree of regional difference through partial assembly by the distributor. It seems likely that the lowest costs will be achieved when the product is the most fully standardized—*if* a mass market for so standardized a product is developed. If the mass market cannot be fully developed

[9] Burchard, "Prefabricated Housing and Its Marketing Problems," p. 152.

for a highly standardized product, the line of models made up from standardized assemblies should prove to be the most economical. Undoubtedly, there will also develop a substantial market for simpler components such as panels, manufactured for general distribution as a sort of superior building material and for assembly by the local builder or architect. Unless a large project is being developed at one time, however, this pattern of operations will almost surely lead to somewhat higher cost to the ultimate consumer in return for increased individuality. Finally, even those who prefer and can afford to have their houses built individually for them will take increasing advantage of the availability of manufactured assemblies and components.

F. Optimum Level of Standardization

The previous question tends to become one of the optimum level of standardization: whether at the 4″ building material module, the modular panel, the three-dimensional section, or the completed house. Undoubtedly all will be under development at the same time, and ultimately all may be the basis for a true mass production. The 4″ module can be assumed to be already well on the way towards this goal, and it might be argued in any case that differences in the character and purpose of its development rule it out of this discussion. These are differences, however, only in degree.

G. Duplication by the Conventional Builder

Overriding all these problems, from the point of view of the prefabricator as we now know him, is the problem of the ease of duplication and the adoption of his new techniques by the conventional builder. The conventional builder has been criticized by many as old fashioned and unlikely to compete along the paths of industrialization. Actually, as we have seen, many industrial techniques are already turned to his use as well as to that of the prefabricator. Aluminum siding and roofing are widely marketed. Even the highly industrialized vitreous enamel finish can be purchased for home use from manufacturers. Such vitreous enamel sheets are thin enough

to have many of the characteristics of wallpaper. It is this quick utilization by others of his developments which illustrates that the prefabricator may serve primarily as an agency for the first substantial penetration into the building industry of modern mass-production theories.

IV. Larger Housing Issues

Lord Kelvin has said that one measurement is worth a thousand questions. In the prefabrication field, as in many others, this is not always true. With relation to some of the most important forces bearing upon the future of housing, even the basic theories have hardly been developed. For those dealing with such forces, one question may be worth a thousand measurements. It is the purpose of this section to raise some of these questions. These are often easy questions to ask; unfortunately, for most of them there is little indication of a satisfactory answer.

A. The House Itself

1. Shrinkage

The house in which the average family lives has been undergoing a steady change in character in recent years. More and more of the functions which used to be performed within its walls have been transferred elsewhere, while in some degree there has been a replacement by functions not previously considered part of the house. Thus food preservation and preparation require a very small portion of the time, energy, and space formerly devoted to such activities. The recent introduction of the home freezer and of other specialized kitchen equipment represents not so much a reversal of this trend as the provision of new types of conveniences. Rooms for formal entertaining and space for making and washing clothes have been

curtailed sharply, and, here again, the recent growth in popularity of home entertainment devices and sewing and washing machinery takes the form of an added service for those to whom the commercial facilities were unsatisfactory. Space needed for heating equipment and fuel has been sharply reduced; servant quarters are fast disappearing; and rooms themselves are becoming smaller. All this has been reflected in a contraction in the size of the "average" house over the course of the last few decades.

In the future, to what degree will this shrinkage continue? Are there practical limits to the reduction of meal-preparation and eating space, or will there be a further contraction, possibly with the development of precooked and fresh-frozen full-course meals, specialized catering services, and the like? Will families go out for more and more of their entertainment, using the automobile to get them to commercial and community recreation centers, or will the radio and television bring them increasingly back into the home? Large formal occasions tend already to be celebrated out of the home in rented quarters. Will this be true for smaller occasions also, as better social rooms become available on a neighborhood basis?

This list of questions could be expanded, but it is enough to illustrate the point: an increasing reliance on the community means not only a shrinkage in the size of the house, but also an increasing community influence upon the family enjoyment of the house. The successful prefabricator will be prepared not only to modify his product, but also to pay increasing attention in selling, locating, and erecting his houses to the character of services now being performed by the community.

2. Mechanical Independence

Will there be an increasing trend towards mechanical independence? We know that, although families are steadily moving into the large metropolitan areas in this country, within these areas they are moving rapidly out from the centers to the suburbs. This suburban movement has been speeded by the automobile and by the availability of electric power, and a boost was given by such mechanical appliances as the washing machine and the home freezer. Will there be a further development along these lines with further decentralization, or will peacetime living bring a return to the prewar inclination to purchase services from specialized and centralized

organizations? For example, if it were possible to have electric power as cheaply from a home generator as from public service companies, would the average family wish to have this added independence? An efficient and economical chemical toilet, with or without the re-use of the water, could make significant changes in the construction of the house and even in the structure of the sewer-bound society in which we live.

For the average person an increased provision of home machinery and equipment might be attractive, but it would substantially increase the first cost of the house, and this the average family cannot stand. Although in some respects it is not in the best interests of those concerned, the trend towards designing for low initial cost will very likely continue, even in the face of higher maintenance and service expenses. This trend may be reversed principally in the construction of mass housing, whether supported by government or built as an equity investment; in either case there are clear advantages in paying a high first cost which will be more than balanced by long-range efficiency.

3. Flexibility

From another point of view, it is important to know the degree to which the house must be made flexible—to permit changes in size and arrangement with the changes in the composition and character of the family living in it. Many a prefabricator has been persuaded of the need for such flexibility, and, because his construction system offers easy demountability, this tends to be made a selling point. A large segment of the public, certainly, has expressed the desire to add bedrooms, shift plans, and generally have an "expansible house." Yet, it is fair to ask, to what degree is this desire real and to what degree imaginary? How many average householders have carried out extensive remodeling of their houses in recent years? How many more would have done so were it inexpensive and easy to do so? The frequency of family moving in this country may be enough to take care of such adjustments. Family pattern is partly a matter of size and facilities within the house and partly one of location in a general sense (urban, suburban, or rural—to obtain certain definite benefits, real or imagined), of a desire for gain in social status, and of a complex of other factors. If there is no trend to-

wards a fixed location for the family, there may be no particular need for great flexibility in the house.

Where it can be easily provided, however, as by movable partitions, little is lost in terms of cost and much is gained in sales appeal by providing flexibility. Further, if stable communities should develop having a good cross section of types and sizes of families and serving them well enough to reduce the urge to move, then there might well be advantages for the prefabricator offering flexibility in the form of standardized building components for individual assembly and easy reassembly according to need.[10] On the other hand, several prefabricators propose to offer frequent new and improved models and to persuade the homeowner to trade in his present house for the latest model. This would offer another sort of flexibility, if it were easy to detach houses from the land and trade them about like chattels, or if land planning trends and social developments in the future should make it less of a problem of adjustment for a family to find a new location for each new house. If models were traded in only at the time of major family changes or moves, of course, the problem would tend to take care of itself, since these changes often are accompanied by changes in location preference within the community. For example, young married couples like to live in central locations, while parents of small children prefer open development, freedom from traffic, and suburban informality.

4. Single-Family or Multifamily Units

Another important question is this: will the mass-produced units of the future be single-family or multifamily houses? It is often claimed that multifamily homes can be offered at slightly less cost, and that, with the benefits of the best of modern design, they offer certain advantages to the family. In fact, when it comes to very

[10] Suppose a family, growing through the years, has reached the stage of adding a "Cadillac grade" mechanical core and a great deal of living space enclosed by standardized wall panels. Then, when the daughter marries and moves away, it becomes possible quite literally to break up the old home, giving her the old "Ford grade" core and enough panels for a small house in which to begin married life. This kind of speculation tends to minimize the problems of foundations, gardens, and land use in general, but it has a certain fascination, nevertheless.

small units occupying narrow lots of land, many feel that multifamily units are definitely superior, offering better space with increased privacy. High apartments also have their strong advocates. Yet the prefabrication industry has attempted very little as yet along multifamily lines. This situation will be altered in the near future, no doubt; construction systems will increasingly be made adaptable to multifamily structures; and for the high fireproof structures, special systems will be worked out to take advantage of components adapted also to simpler construction. These developments will be accompanied, and greatly abetted, by two other developments: the growth of modular coordination and the increase of low-cost project-type housing built by public agencies, by large developers aided by the government, and by equity investors such as the large insurance companies.

5. Durability

What is the optimum durability of the house? Prefabricated houses have in the past suffered from a popular belief that they were "temporary" houses, when the fact is that the industry might better wonder whether it has not been building too well. Two arguments are often put forward in favor of decreasing the length of life of the average house. The first is that long life means rigidity, whereas family requirements change, land use patterns change, and our whole way of life changes; in short everything changes except the house in which life is supposed to take place, and that is altered only by the addition of mechanical equipment and conveniences and by minor adjustments in the details. The second argument is that if houses were less durable, more would have to be replaced each year; the building industry would have a larger constant core of replacement building; larger-volume production would in turn lead to more efficient production; and fluctuations in building activity would be less extreme. The first argument can be answered in part by flexibility and good planning, and the second may be challenged on the basis of cost and practicality. Can the nation afford to replace housing on the basis of a life span of definite and rather short length? The advocates of greater replacement might ask whether it can afford not to do so. However, the building of a house calculated to last an exact number of years is no mean feat, and experience with temporary structures in the past has shown that the life of a

house depends more on maintenance standards than on construction standards. Enforced replacement is hardly an immediate prospect.

6. Obsolescence

To this must be added another question, that of obsolescence. Whether we like it or not, the fact is that most of our large-production industries depend in part upon a rapid rate of obsolescence. This may be natural for some products, but it is largely artificial when it comes to radios or automobiles. Actual or pretended improvement in performance leads to a demand for the new product while the usefulness of the old one continues largely unimpaired. Something of this sort is very likely to appear in the prefabrication industry in the future, and it may have an important bearing on the question of durability as well. Would one build an automobile to last 60 years if constant or significant technical improvements were anticipated? But obsolescence will not become a major force unless there is also developed a second-hand market. A house goes into use only after it has become a piece of real estate, attached to a certain piece of land. A second-hand market in house packages would require that dealers become real estate operators on a large scale in order to put the houses quickly into use, and that land use and home-owning customs undergo a sort of revolution. This is not impossible, of course, but it does not seem likely to come to pass in the near future, at least in anything like this form. It seems far more likely that any second-hand market which develops will follow the lines of the traditional real estate market,[11] and that there will be little selling of used houses without lots for some time to come. The costs of moving houses and making and breaking utility connections are too great, although we have seen that new developments may one day take care of even such problems as these.

[11] It may be noted in this connection that the new president of Gunnison Homes, Inc., is a man with vast experience in handling real estate.

1. General Problems

In addition to an understanding of the changing character of the house itself, the prefabricator must have an appreciation of the extent to which it is dependent on external factors for satisfactory performance. Two quotations from experts will serve to give an indication of the factors involved. William J. Levitt, the well-known Long Island builder, points out:

> There is no such thing as a complete, factory-engineered house—because no one has discovered how to prefabricate the land, how to prefabricate the road in front of the land or the water main that goes into the house.[12]

Russell W. Davenport, moderator of the *Life* Round Table on Housing, concludes that most of the trouble with prefabrication lies in the nature of the product itself.

> A house, in short, is not merely a mechanical product; it is not even merely a physical or material product—though even on this plane standardization and mass production are difficult. A house transcends the physical and transcends the tangible to become part of its surrounding civilization. It is a civic or social product; and for those who live in it it has a spiritual significance. These elementary facts must constantly be borne in mind if our efforts to house ourselves better are not to meet with disaster.[13]

Many aspects of his market are beyond the control of the prefabricator, no matter how large he may be, and can be influenced only by public understanding and action—for example, a boom in speculative land prices, a series of municipal "protective regulations" which in effect require excessive development costs, or a blight of excessive land subdivision and clouded land titles. The prefabricator should, however, make his plans and conduct his operations with an intelligent regard for these broad problems.

[12] *Life*, 26 (January 31, 1949), 74.
[13] *Ibid.*, 78.

2. Future Demand

One important element of his plans is the estimation of housing demand in the future. This is the most complex sort of problem, involving as it does everything from consumer tastes to government policies, and yet market-analysis techniques and data are woefully inadequate. Important considerations are the supply of existing houses and the measures provided for the demolition of those houses which are obsolete. The industrialist may argue that disposal of the obsolete will follow naturally from an abundant production of the new. If the obsolete drops sufficiently in price, however, and is usable, can the new reach abundant production? How does this take account, moreover, of the investment in developed land, utilities, and community services? How long can we afford to concentrate new development on the outskirts of our cities and let blight move in behind? These may be the problems of the city planner and the investor in real estate, but they are also the problems of any mass producer of houses.

3. Competition from Existing Houses

The housing market displays the characteristic of rapid obsolescence at the top and very slow obsolescence at the bottom. When houses have become actually unsuited to human habitation, energetic exercise of the police power will suffice to tear them down. Above this level, however, they remain a problem and a source of competition for any type of new housing. As a result, the prefabricator may decide to operate at higher price levels, counting on producing new models attractive enough to entice former purchasers to trade in their old houses. In this way the old houses are to be started on the "filtering down" process by which low-price housing becomes available at second, third, or fourth hand to those who cannot afford to purchase new houses. In the automobile field, this process works, and one can purchase a car for $200 which is far better than a new one built to sell at that price. In the past, however, the houses which have filtered down in this way have been too few and too poorly adapted to the need of those in the lower-income brackets. Much will depend in the future upon reaching a low price level for new houses, so that they may have a broad market from the start. Otherwise, prefabricators hoping to serve the whole range of hous-

ing needs will have to trade purchasers out of their new houses at an impossibly high rate in order to start secondhand houses down the line in sufficiently high volume. Large-volume production might thus require such a combination of low price and high sales appeal that the old house will be traded in as often as every 10 years; otherwise the prefabricator may become the victim of the housebuilding cycle as it has operated in the past.

4. Problems of Turnover

There are many difficulties in obtaining a rapid turnover of this sort. One is the likelihood that the new features upon which the manufacturer must rely for sales appeal will tend to be mechanical equipment and gadgetry which may relatively easily be purchased and installed in the old house, the shell of which is likely to deteriorate at a slow rate by comparison with its equipment if the level of maintenance is good. Another is the fact, which cannot too often be mentioned, that houses are attached to the land. Unless houses can be made demountable and sold through secondhand dealers like automobiles,[14] the purchase of each new house means moving to a new site, and usually a new neighborhood. What does this imply for the stability of communities, for the interest of people in the local governments and schools, and for those—especially children—who find adjustment to new social circles a personal strain? What happens, as a practical matter, to the well-kept lawn and the garden? If we avoid providing for expansibility or demountability because we expect our current high degree of family mobility to be maintained, then we must provide correctives for the problems which such mobility creates.

5. Community Planning

Broad problems facing the prefabricator often stem from problems of community planning. The rapid development of a large outlying tract with hundreds of similar small houses and insufficient community services and amenities, which appears to be the most eco-

[14] For an examination of this idea, see Neal MacGeihan, "The Myth of the Low Cost House," *Prefabricated Homes,* January–February 1945.

nomical manner of providing houses in terms of first cost, may in the long run so prejudice the housing market that the effects will be felt by the prefabricator himself. He must seriously consider whether this sort of entirely unofficial zoning into a one-class, one-income, undifferentiated community may not be contrary to his own selfish interests because of the dissatisfaction of those living in such a community—almost certain to be carried over to the house itself. At present, few have had to worry about these problems, because few have attempted mass production on such a scale and with such equipment and plant that profitable operation over a period of years is required if the investment is to pay off. In the future, unless the large producers consider such matters as they grow in stature and importance, public opinion may compel the local government to take steps to control them, and they run the risk of becoming in effect large public utility companies. Through intelligent planning, volume of sales can be maintained at a high level without injury to the community from which the houses derive so much of their essential character and quality.[15]

C. Broad Economic and Policy Problems

Much that might come under this heading has already been touched upon, but there remain two aspects of the relationship of the government to prefabrication which deserve consideration here. Already committed to a public housing program and to a program of mortgage insurance which leaves the building of many small houses a matter of private enterprise in name only, the government is taking an increasing interest in the general field of middle-income housing, the field of greatest interest to prefabrication.

1. Government Aid

Government aid is not peculiar to housing; it has been widely used in many fields in the past. The automobile industry, our prime

[15] It should be noted that increasing attention is being paid to these matters of neighborhood planning. The checklist for veterans in *For the Home-Buying Veteran*, issued jointly by the several federal housing agencies in 1949, makes the character of the neighborhood and the character of the lot the very first two matters of concern.

example of mass production, could hardly have developed without a tremendous subsidy in the form of public roads.[16] The day may come when the government will adopt the often-suggested policy of establishing a figure below which the production of housing would not be allowed to fall; under such a policy, if the necessary houses were not produced by private means, the government would take over at once. The importance of such policies, and of the government guarantee of decent housing, will become increasingly large factors in the future as the prefabricators grow in size and in volume of production. Self-interest alone should induce the leaders in the field to take a constructive part in the formulation of broad plans and to cooperate with the government in setting up that stable market situation which is necessary for profitable operations.

2. National Capitalism

One aspect of government housing policies which secures a great deal of attention in business and industrial circles is the emergence of what has been called national capitalism. In the past, the housing industry has been considered a bulwark of private capitalism, but there can be no doubt that this is being altered. The problem is, To what extent? Of particular interest in this connection was Lustron, organized to produce houses at a scale never before realized, and financed initially with $840,000 private equity capital on the one hand and a $15,500,000 loan from the RFC on the other. With no further increase in private equity capital, the public loan later more than doubled, and requests were submitted for increases to as much as $50,000,000. With a ratio of better than forty to one of debt to equity, this leverage seemed so great that it was said that for all practical purposes the government had gone into the housing business.

Many private businessmen were concerned; they believed that Lustron had received "favorite son" treatment. Either the government plans deliberately to take over the housing industry, or it will eventually take it over whether it plans to or not, they argued. Who would dare to raise the risk capital and create the facilities necessary to compete with Lustron on an entirely private basis? The government

[16] It has been suggested that this theory be carried over into the housing field, and that the government frankly subsidize housing by the purchase and free grant of house sites, retaining thereby the control of development.

would surely continue its favored treatment in order to protect a 98% investment. With private capital thus frightened out of the housing industry, the government would move inevitably towards national capitalism. Claiming to favor free enterprise, but becoming increasingly addicted to close regulation and control, the government might continue to solicit private capital, but would certainly put up public capital if none were forthcoming.[17] And eventually the same mechanism would be turned to other fields, said the worried spokesmen of business.

On the other hand, there can be little doubt that many who had approved governmental support of Lustron were quite free of such motives. Prefabrication is a young industry, and we have seen that financing on a tremendous scale is often required for the mass production and distribution of houses. The risk is so great and the prospects of profit so dim in comparison with other investment opportunities that only the government, acting in the broad interests of the public, can be expected to give such an industrial approach a real test. When the way had been shown, supporters expected private corporations to move in quickly and set up competitive enterprises, and meanwhile Lustron should itself have repaid the RFC and become a private industry in the normal sense. Certainly one can sympathize with the desire to give any likely method of increasing production and reducing costs a fair chance to prove itself. If operations should prove extremely profitable, why would large companies avoid the field? They have had to deal with the government before.

[17] In his testimony of August 5, 1949, submitted to the House of Representatives Banking and Currency Committee, Harry H. Steidle, Manager of the Prefabricated Home Manufacturers' Institute, had this to say: "We are therefore strongly opposed to legislation that would definitely favor any one of several companies that are heavily indebted to the Government to the disadvantage of those companies which are in part paying the bill through taxes. . . . This pattern of destruction to privately financed producers of prefabricated homes shows itself in numerous ways, some of which are as follows: (a) in the compulsion to extend further loans in hope of working out of an already bad situation; (b) by the practical effect of extending free rent from the War Assets Administration; (c) through intercession before other governmental agencies for the allocation of steel or other aids not available to privately financed companies; (d) through authorization of a large sales and public relations staff paid out of Government loans; (e) by approval of a national advertising campaign paid for out of Government loans; (f) through pressures of varying degrees exerted on Government buying agencies to purchase the houses made by the indebted company." The legislation in question, which would have authorized RFC marketing loans to companies already holding RFC loans, was defeated.

It is too soon to know what the eventual result of the intervention of the government will be. The fully equipped Lustron plant has great potential value as a producer of houses, of bathtubs and sanitary ware, and of light structures in general. It contains probably the world's largest ceramic line. Dismembered and sold at auction, it would bring the RFC only a few cents on the dollar. Yet the political interest which has been aroused makes it unattractive to private investors, and competitors are standing in the wings, fears of national capitalism notwithstanding. United States Steel Corporation owns a controlling interest in Gunnison Homes, and its Ambridge research laboratories are at work on housing problems. Republic Steel Corporation, through its Truscon division, already supplies a great variety of components to the housing industry. The aluminum companies have nearly all come out with lines of building materials. All could move in fast and make a good fight for the business. Some undoubtedly prefer to avoid making houses as such and, by manufacturing a line of highly developed components, plan to take over most of the business without direct competition.

As a sidelight on this question, it should be pointed out that many public housers seemed to dislike Lustron with an intensity approaching that felt by these businessmen. Conscious of limited objectives and unintelligent actions on the part of private builders in the past, they were inclined to dismiss as technocratic pipedreams all efforts to reduce the capital costs and to increase the supply of housing by processes of industrialization. While it is true that there has been some justification for a healthy concern, it seems illogical to be suspicious of any approach to an increased supply of better housing which does not involve public agencies and project developments. Between the suspicions of housers that Lustron was a mere attempt to discredit the public housing program through a cynical mass-production mythology and the suspicions of the businessmen that it was the first step in socializing the industry, the company had plenty of intangible difficulties to add to its normal production problems.

A final note on these relationships: few business suspicions regarding the future seem to attach to the work of such government agencies as the FHA and the VA, through the combined resources of which it is possible for private builders to put up houses without the investment of any private equity risk capital whatsoever. Here the initiative remains in the hands of the local builder, it is true, and the financing is worked out in local circles, so that the process appears to be more conventional. But at the first major break in prices and employment, the government will take over a large share of our

housing supply. Clearly, the government program needs to be considered as a whole.

V. Conclusion

A number of questions have been raised in this chapter, but the problems extend beyond any single set of questions. Above all it should be clear that the prefabrication industry faces problems of very great variety, many of them far more complex than is generally recognized. To analyze these problems and to work out the means of finding significant answers is the job of research, and no one can doubt that a great deal of research is needed. By and large, the technical questions, while easier to answer, tend to seem almost unimportant by comparison with broad questions of economics and sociology. And yet even technical questions often require great skill and patience. For research is always a long process—in building especially so—and it is even longer before practical application takes place.

Those familiar with the state of knowledge and research at any time can make fairly accurate predictions regarding the developments likely to occur over the next period of years, subject only to accelerations and decelerations resulting from such factors as wars and depressions. Everyone is aware of the detail in which such imaginative writers as Jules Verne and H. G. Wells were often able to forecast events which have since transpired. Ordinarily, there is a substantial time lag between the day when knowledge justifies a prediction and the day when the prediction comes true. The existence of this time lag makes it possible in normal times to foretell whether or not magical industrial advances are likely to take place in a given field in the next few years; there is little in the current state of building knowledge and research which suggests that any such advances may soon be expected. It is largely this belief that we were in a period of comparative calm which served to justify us in exploring in so great detail the existing state of the industry.

For such new ideas as may now have reached the stage of clear anticipation, there remain long periods of development to be under-

taken, first in the laboratory, and later at pilot plants. Such is the skill of modern engineering, however, that this process could be carried out easily, provided enough money and energy were put behind the development. Yet, with technical development completed, the new idea must buck other forces which oppose the introduction of any innovation—the so-called barriers to technological advance which have frequently been described.[18] For even the simplest ideas, therefore, a widespread application may be long delayed.

Most of the ideas in prefabrication, furthermore, are not simple. They involve questions many of which could be answered comparatively easily if they could be put in direct, technical form; the trouble is that in this field few questions can be put in that form. To illustrate this point, take the question of corrosion. Prefabricators with corrosion problems may draw on scientific facts which have been well established for years, but they are more concerned with satisfactory performance at low cost than with scientific advances. The basic research in corrosion is therefore primarily conducted in laboratories little concerned with the problems of housing.

This illustration might be multiplied, but it will suffice to point up the fact that little scientific satisfaction is available in the field of housing, where every problem is confused by considerations of economics, sociology, physiology, and psychology. The result is that, in the universities and elsewhere, research men have preferred less complex and more satisfying problems.

During the war it was possible to attract to government war research a great number of the best scientific minds in the country, despite the fact that their work, with very few exceptions, was not scientific research at all, but rather the accelerated development, for war purposes, of scientific knowledge derived from research done as much as two generations earlier. Unquestionably there is an emergency in housing today, but the sense of urgency and of overall organization along lines of clear and definite policy has been missing. Such research as is being done frequently represents a search for suitable compromises limited by the special interests of sponsors, by lack of resources, and by the absence of programs broad enough to challenge assumptions and seek far afield for determining forces.

[18] See, for instance, Bernhard J. Stern, "Resistances to the Adoption of Technological Innovations," *Technological Trends and National Policy,* National Resources Committee (June 1937), pp. 39–66.

We have pointed out that when an entirely new product is developed a new industry will often be created. But houses are not new products, and they cannot quickly be "rationalized." Men may select a radio with a relatively dispassionate logic, but emotions and traditions tend to dominate in the choice of a house. Obviously, careful sociological research is needed even to identify the main drives operating in this field, and much more research will be needed before we know how to direct these drives, or to what ends. At the present time, the beginnings of sociological studies in housing have been made. Of especial interest are recent studies made by the Research Center for Group Dynamics, of the University of Michigan,[19] and by Robert K. Merton at Columbia.[20] The work has barely been begun, however.

Far more is involved than the tabulation of preferences regarding the size and arrangement of rooms. It may one day be shown, for instance, that satisfaction with a house depends less on the character of the house itself than on the social relationships formed by the family. The market may grow in the future for well-planned projects of small houses balanced by good neighborhood facilities. Even such broad considerations as full employment and increased leisure will have their influence on the product and on the industry.

Lacking basic and fundamental facts in all these situations, we may seek empirical data on which to base decisions in the immediate future through a careful analysis of the activities of such producers as Lustron, such builders as Levitt and Sons, and such government activities as those of the FHA and the FPHA. In the past, following a national tradition of never looking back, we have been guilty of shocking waste through our failure to profit from the great experiments and projects we have built. We can no longer afford such extravagance.

H. G .Wells pointed out that the rapid rise of the Germans in national strength and importance in the nineteenth century could be attributed in large part to their discovery that knowledge was a crop like any other, to be increased in quality and in yield by cultivation and by the intelligent use of fertilizers. This lesson the recent war

[19] Their original work in this field, sponsored by the Bemis Foundation, is described in the book by Leon Festinger, Stanley Schachter, and Kurt Back, *Social Pressures in Informal Groups: A Study of Human Factors in Housing* (New York: Harper, 1950).

[20] Reference to many other studies may be found in "Selected References on Family Living Requirements and Public Acceptance Factors Relating to Housing Design," *HHFA Technical Bulletin*, no. 4 (April 1947).

has finally brought home to us in this country; let us apply it in the field of housing.

One may ask who should do the research work: private companies, industrial associations, educational institutions, professional societies, or government agencies? Obviously, the answer is: all of these, in a coordinated effort.

All now are needed, and the way seems open at last for all to take part. Private producers are becoming large enough to devote serious efforts to research; industrial associations are growing in importance; educational institutions have increasingly entered the field; professional societies have taken initiative indirectly and directly in the stimulation of new research, as typified by the formation in the National Research Council of the Building Research Advisory Board; and the government is now provided with legislative authority for a large-scale program of research in the HHFA.

The importance of prefabrication in helping to stimulate this research effort lies in the fact that, because of the problems inherent in adopting and executing a suitable pattern of operations covering every step from the procurement of raw materials to the servicing of the final houses, it has brought sharply into focus the needs for research, the possibilities and difficulties of industrialization, and the special complications of the production aspects of the housing problem. To return to the thought expressed in the introduction of this chapter, it may well prove in the end that prefabrication has been only a local and specialized advance within a broad process of industrialization, and that in the future there will be little point in trying to decide whether or not a housing process can properly be called prefabrication. The prefabrication industry has served, however, as an almost ideal framework in which to study the overall problems of housing.

Part II.

Chapter 5

INTRODUCTION

This part of the book is devoted to a detailed and, as nearly as possible, factual and objective analysis of 130 of the prefabricators whose production facilities were visited and representatives of whose management were interviewed during the course of an extended field survey.[1]

No one survey could give the definitive story of prefabrication as a whole; yet it has been possible to describe in some detail the activities of a large and entirely representative portion of the industry. All but a very few of the leading companies are included in the 130 analyzed, and a particular effort was made to include companies promising the greatest innovations, whether or not they were in actual production at the time.

In this analysis, the various methods, designs, and facilities are discussed primarily in terms of the number of companies making use of them. This was a necessary procedure, for accurate information on production was often not available, and in many cases the value of an idea could not be fairly judged by production figures. Analysis by numbers of companies also has its weakness, however. If Lustron had reached its expected rate of production, for example, it would be making more houses per year than have been sold by the entire industry in any single year in its history. From the viewpoint of the general housing market, therefore, a decision by this one company might have importance far beyond the apparent meaning of our figures. On the other hand, our principal interest in this part of the book is in finding out what patterns of operation were being used at the time when the greatest number of companies was active in the field. This sort of information can best be approached by the method which we have adopted.

The discussion is broken down into a consideration of five basic components of a pattern of operations:

Management
Design
Procurement
Production
Marketing

and the treatment is factual wherever possible. Factual treatment is not always possible, however; for example, the prefabricators'

[1] Material regarding the methods used in this survey, lists giving full names and addresses of companies visited, and other reference data are included in the Appendices.

thoughts regarding the government or labor can be reported only as opinion, although it is opinion based upon interviews, press statements, and actions they have taken.

The bulk of the material in this part of the book was gathered during the Bemis Foundation's field survey in 1946 and 1947, but references to more recent developments have been included when these would help to give a full understanding of the problems involved or of the trends within the industry today.

Because of the organization scheme which has been followed, there is in this part of the book some duplication of material presented in the first part. There, the references were usually brief, however, and they served primarily to illustrate general points under discussion. Here, interest is centered on specific details of the prefabrication process.

Part II.

Chapter 6

MANAGEMENT

I. Background

Many of the differences in patterns of operations of prefabricators may be attributed to differences in background, that is, in the nature of the business from which the prefabrication business developed and in the previous experience of top management. Unquestionably many costly mistakes have been made by carrying over to this new industry techniques which were more familiar than suitable. On the other hand, background can explain the success of certain companies in dealing with the very specialized conditions of a local market. In the companies analyzed, the following types of background were noted:

	Previous Experience	*Frequency (per cent)*
1	Building contractors, construction engineers, and operative builders	31.2
2	Building materials manufacturers or salesmen	19.5
3	Architects	19.5
4	General manufacturers (including shipbuilding, boxmaking, light metal fabrication, and heavy industry)	17.5
5	Salesmen	6.5
6	Bankers	2.6
7	Lawyers	1.9
8	Other	1.3

Without exploring in detail the relationships between background and the final nature of companies, a few generalizations are possible from our data. In the first group, several companies carried over into prefabrication the organizational characteristics of large contracting operations. Some of these tended, after a short period of true prefabrication, to return once more to the more conventional patterns from which they had attempted to depart, and although there might be many other reasons for this return, familiarity with the old procedures and old friendships undoubtedly exerted their influence. In general, however, companies developed by engineers and builders were not wealthy or large enough to carry out a radical approach to design, even had they wished to do so.

In the second group, particularly among the lumber dealers, the tendency was to regard prefabrication as a mere refining operation for the materials handled. Indeed, during the materials shortages following the war, some never prefabricated houses, but only took

advantage of their favorable supply situation and the regulations of the Office of Price Administration to charge substantially higher prices for performing a few additional operations on the materials as "prefabricators." Others, however, particularly in the major lumber supply area of the Pacific Northwest, made use of their experience with distribution and manufacturing methods to bring a genuine efficiency to the manufacture of houses.

As for the third group, architects have contributed theories more often than they have started companies, and, when they have set up companies, they have often met with difficulties. A few, however, have been aware of the complexities of operating in the house manufacturing field and have been able, usually by marshaling other talents about them, to build good organizations.

The fourth group, with experience in manufacturing enterprises, often had the tremendous initial advantages of well-rounded staffs and good capitalization; some of them, however, have been impeded by their attachment to certain materials or by the deficiencies of their media of distribution. In general they have been characterized by a willingness to try new materials and designs which might be well suited to mass production, and for that reason they have been very important to the industry.

Regarding the remaining three groups, the salesmen, bankers, and lawyers, the only valid generalization that can be made is that both their strength and their weakness lay in their emphasis on detailed organization and salesmanship.

On the whole, the men in top management positions had not been trained in the industry itself, although a few companies had been started or staffed by "graduates" of other companies. This is understandable when it is realized that a man with 15 years' experience could rightly consider himself a charter member of the industry. A breakdown of the industry by length of time each company has been in business will highlight this point, the more so because many of the older firms were really precutters rather than prefabricators. As of 1947, the age distribution data from 118 of the companies in our analysis was:

Number of Years in Business	*Number of Companies*
2 or less	67
3–7	24
8–17	19
18 or more	8

An important recent source of trained men has been the various federal agencies dealing with housing, and there is a trend for increasingly large numbers of men to enter the field from the professions and from special courses in the colleges, in the hope of growing up with the industry.

The size of the staff may be used as a reasonable, if rough, indication of its ability to handle the complete pattern of operations. At the time of our analysis, at least 50 companies were known to have staffs exceeding 15 in number, a number probably adequate for the job. Of those having less, the majority tended to cut out certain services which they regarded as unimportant; architectural services were among those most frequently so regarded.

Fortunately, the minimum requirements of the FHA and of building codes have helped to prevent some of the worst errors which might have resulted from this combination of ignorance and the desire to keep down costs. A few companies have hired consultants to advise them on various aspects of their operations, with the result that a group—very small as yet—of specialists has grown up to serve in this way. Other producers have allied with independent organizations which would distribute their output; these distributors were often land developers as well. Still others have purchased the design, production, and even procurement and advertising services of a parent licensing organization; while a few, offering only design or production ideas, have sought out other organizations with the capital and ability to take over the rest of the operations.

With regard to the function of research, no prefabricator was doing what might be called pure research and very few were doing applied research, although nearly all the 80 largest companies had staff personnel engaged at least part time in short-range product development work. There were 51 companies which had part-time research personnel; 25 had full-time research personnel; and at least 15 had a separate research and development division. Naturally enough, the companies in the process of getting started were the more likely to be engaged in concentrated development work, while those under way tended to abandon research for the more pressing problems of production and distribution, hoping to return to it when their volume could support the expense and when they had had a chance to put their initial designs to a practical test.

II. Labor Relations

In discussing labor relations in the industry a distinction should be made between conditions in the factory and those at the site, for there are substantial differences. Of the industry as a whole, however, it can be said that labor relations have been generally good. Our survey found this to be particularly true in the plants, and a similar generalization has been made by PHMI, which reported that "relations between employee and employer have been uniformly good." [1] True, there have been instances of restrictive practices, but the testimony of the manufacturers seems to indicate that reports of labor opposition to prefabrication have been magnified out of all proportion, and certainly since the end of the recent war there seems to be little justification for the accusation that organized labor as such is holding up the development of the industry. In part, labor's attitude stems from the pledge to cooperate made by unions during the Wyatt program; once good relationships were entered into, most unions found it to their own advantage to continue in this way. Of some import have been such factors as the recent high level of construction activity and the plentiful supply of construction jobs. Probably more important have been the facts that most of the producing units are relatively new and small, and that the volume of the industry as a whole has not yet been such as to attract special labor interest.

Labor Relations in the Plant

A. Unions

The extent to which the industry had been organized at the time of the survey was difficult to determine because the situation was in

[1] Quoted from testimony by Harry Steidle before the Joint Committee on Housing of the 80th Congress, January 14, 1948. Mr. Steidle was referring to conditions in the plant. Austin Drewry, then President of PHMI, described employer-employee relations as "excellent" in his opening address, Fifth Annual Meeting, PHMI, Chicago, March 1948.

a state of flux. The indications were, however, that in 1947 at least two-thirds and probably three-quarters of the industry was unionized, measured either by number of companies or by number of employees. The AFL had organized about seven times as many plants as the CIO, there being several unaffiliated unions also. Among the AFL shops, the most prevalent union was the United Brotherhood of Carpenters and Joiners of America. Several plants were organized by such affiliates of this brotherhood as the millmen, boxmakers, or lumber and sawmill workers, who had less of a craft background and lower wage rates than the carpenters.

With the advent of increasing industrialization in house manufacture, and particularly with the increasing use of materials not traditionally handled by union members in the housebuilding trades, the CIO began to organize prefabrication plants. For a while it made some progress, aided by manufacturers who sought an end to the restrictive practices of craft unions, and occasionally by the circumstance that an existing union organization might be carried over from another enterprise which had previously occupied the same plant.[2] More recently, however, the CIO has lost ground, at least relative to the AFL. A substantial obstacle in its path has been the trouble sometimes encountered in the field where AFL labor used for erecting the house refused to handle material made by CIO labor. Another obstacle was the task of organizing trades such as those of the plumbers and electricians which have traditionally been organized along craft rather than industrial lines and have been saturated with craft attitudes. A not inconsiderable factor in explaining the relative halt in the CIO's organizing drive has been the failure of some of the prefabricators using metal, many of whose plants the CIO had organized.

One important effect of the CIO's organizing drive, however, was to provoke the AFL into meeting the challenge. AFL unions have entered into a number of agreements which indicate the AFL's determination to retain its position in the residential construction field, even in its most industrialized aspects. Contracts with some of the larger prefabricators such as Gunnison, National Homes, Pease, and Lustron, and with Borg-Warner are examples. The last two cases illustrate the special effort made by many prefabricators to secure union support. Borg-Warner went to the plumbers' union at an early stage and secured the endorsement of the international office on the idea. This company further went to the point of employing a

[2] For instance, two prefabricators were organized by the Industrial Union of Marine and Shipbuilding Workers of America, CIO, for substantially this reason.

man with a craft union background to handle relationships with the master plumbers, through whom it distributed the Ingersoll Utility Unit, and to participate generally in the labor relations between plant and field. In the factory, contracts were made with the plumbers, sheet-metal workers, and electricians. The Lustron management also requested unionization from the start; an agreement was made with three AFL unions to cover the whole building process, and it may stand as an example of the growing trend towards reducing the number of craft unions engaged in one building job; in this case lathers, plasterers, and painters were eliminated. The contract was made with the international offices of the carpenters, plumbers, and electricians in November 1947 and was featured at the 1948 AFL convention as a sign of labor's willingness to cooperate. It provides for a union shop, for uninterrupted production and efficient erection at United States and Canadian sites, and for the avoidance of jurisdictional disputes by limiting the number of crafts and by including the pledge of the international office to advise locals and enforce the contract.

B. Wages

As might be expected, wage rates in the plant generally appeared to be lower than those in the field for several reasons. First, the order of skills required is lower. Second, there is longer and steadier employment and therefore the likelihood of better annual take-home pay, both because of less seasonality in the volume of work and because of a lower rate of turnover among jobs. Third, working conditions are better. A rough measure of the difference which existed between factory and field wage rates is given by the following figures: average earnings per hour of employment in 38 prefabrication plants working in wood in July 1947 were $1.14,[3] while average earnings for carpenters in all private building projects at the same time were $1.58.[4] In industries somewhat allied to prefabrication, however, factory wages were lower: furniture and fin-

[3] PHMI *Survey of Prefabrication Activity, 1947.* (Actually this figure is a bit high since it includes a small amount of overtime earnings.)

[4] *Monthly Labor Review,* 65 (October 1947), 509. The comparison cannot be exact since the averages conceal rather large geographical variations which are not weighted equitably for purposes of comparison. Prefabricators usually more closely approach project rates of their own areas.

ished lumber products, $1.059 per hour; lumber and basic timber products, $1.033 per hour.[5]

Some elements in the carpenters' union have gone on record against this differential in wage rates,[6] but, notwithstanding this, there seems to be a trend towards paying union labor in the factory at a lower hourly rate than members of the same union receive in the field. (Of course, the annual pay may be the same, or higher.) In the Kaiser Community Homes plant at Los Angeles, in February 1947, the several hundred plant employees came under a specially negotiated contract calling for an AFL closed shop. All plant men, with the exception of about 15 painters, came under the agreement made with the International Office of the United Brotherhood of Carpenters and Joiners of America, rather than with any local.[7]

Inasmuch as a good many plants must still hire hands on a seasonal basis, they are not yet entitled to contend that wage rates should be lower on the grounds that they offer stabilized employment, although other arguments may be valid. Where prefabricators have demonstrated the stable nature of their operations, the car-

[5] *Ibid.*, p. 500.

[6] ". . . Therefore, be it resolved that the United Brotherhood of Carpenters and Joiners of America immediately put into force and effect the prevailing construction carpenter's wage scale for all work performed within the pre-fab, pre-cut and mill industry which is normally performed on the job site by construction carpenters."

Resolution No. 13, approved and endorsed by the San Francisco Bay District Council of Carpenters, the California State Mill Committee, and six California locals, *Proceedings of the Twenty-Fifth General Convention of the United Brotherhood of Carpenters and Joiners of America* (Lakeland, Florida, April 22–30, 1946), p. 396.

[7] Certain jobs in the plant required journeymen carpenters' rates: those which would ordinarily be carpenters' work if done in the field. Jobs such as nailing framing members or cutting rafters earned a basic field rate in the plant, for instance, but the slightly different circumstances yielded a somewhat lower final rate of pay than the outside rate. Men in the plant got vacations with pay, however, while field carpenters did not. On the other hand, field carpenters received double pay for overtime up to the first four hours (45-hour week, generally). Millmen, affiliates of the carpenters, but included under the one agreement like all other men in the plant, ran the jointers, bandsaws, etc. Those who stapled plywood onto framing, ran the portable sanding machines, and did other semiskilled tasks of a repetitive nature received 33¢ per hour less than journeymen's rates. Others who came under the carpenters' agreement were the cabinetmakers, the lumber handlers and millhelpers (members of the Lumber and Sawmill Workers local affiliated with the Brotherhood), clerks, and checkers. Plant foremen received 12½¢ per hour more than the journeymen carpenters, but 5¢ per hour less than a comparable job in the field. In general, it appears that wage rates paid in the plant were slightly lower than those paid at the site.

penters, through their international office, have in some cases entered into contracts which establish the principle of differentiation between field journeymen and factory journeymen rates of pay for performance of the same type of work. Two trends thus seem evident: a decrease in the number of unions with which the prefabricator has to deal, and a growing acceptance by trade unions of different wage rates in different conditions of employment, even for the same type of work.

Nor are these the only signs of change introduced by the prefabricator into the whole pattern of industrial relations in the housebuilding industry. There is the growing acceptance of many of the welfare provisions which have for a long time been incorporated into union-management contracts in other industries, such as paid vacations, health insurance, and retirement plans. PHMI found in 1947 that 33 member companies had one or more of the following: [8]

	Number of Companies	*Number of Employees*
Life insurance	12	1,146
Health insurance	20	2,357
Paid vacation	26	2,624
Retirement plans	3	497

In addition, PHMI found that 15 companies employing 1,347 workers had wage incentive or bonus plans of one sort or another—again indicating that old patterns in the building trades were being changed.[9]

In the past few years there has been considerable discussion concerning the guaranteed annual wage. The CIO has taken a strong position in favor of such a plan for the building industry,[10] while the AFL has voiced equally strong opposition, holding that building is clearly a field in which a guaranteed wage plan cannot be made to work.[11] The recent experience of prefabricators with the problems of stabilizing sales, procurement, and production has quite naturally led them to consider any such scheme a grave risk. While the issues involved are complex, it does seem evident that the guaranteed an-

[8] PHMI *Survey of Prefabrication Activity, 1947.*

[9] *Loc. cit.*

[10] Testimony of R. J. Thomas, President, United Automobile, Aircraft and Agricultural Implement Workers of America (CIO); Chairman of the CIO Housing Committee, given before the Senate Special Committee on Post-War Economic Policy and Planning, 79th Congress, 1st Session (*Post-War Economic Policy and Planning,* Part 10, pp. 1678–9).

[11] William Green, "Your Postwar Income," *American Federationist,* 52 (April 1945), 32–3.

nual wage is still far from realization in the industry, because of the AFL's dominance in prefabrication, the general opposition to the scheme by the building-trades unions, the prefabricator's struggle to overcome seasonality (which has thus far been but partially successful), and his often insecure financial position.

C. Restrictive Practices

Despite the generally good labor relations in the plants, there have been instances of restrictive practices on the part of unions at this level. The testimony of certain manufacturers who related particular incidents must be weighted more heavily than the flat denial of such practices by some union spokesmen. Six companies stated that they were prevented from spraying paints in their plant because of union opposition, while others had spraying time severely limited. Whether the union's usual objection that spray guns are not safe from a health standpoint was adequately met in these cases is not known, but paint spraying can be made safe in a factory, and it is a fact that spray guns were known to be in use in seven AFL plants. Some 15 companies stated positively that they were prevented from prefabricating plumbing of any sort because of union opposition. Many more were probably affected. In the case of plumbing, however, it is difficult to separate union opposition from what might better be termed resistance to a change in conventional plumbing material distribution methods, since the two are usually tied together, and from the effects of local building-code regulations. Twenty-seven companies stated that they had refrained from prefabricating plumbing because of a combination of these factors. Master plumbers have a natural interest in opposing the prefabrication of plumbing, since its logical course is to reduce or eliminate their sales of fixtures and supplies in connection with their installation work. Prefabricators were able in some cases to make arrangements with master plumbers to fabricate plumbing assemblies in the plant through what amounted to a royalty agreement with the master plumbers. On the other hand, at least 27 companies were known to be preassembling plumbing and six companies were known to be precutting it, which indicates that a new pattern is evolving and that through persuasion and compromise some of the opposition is disappearing as time goes on.

There have also been cases where, because of definite opposition from the electricians' union, wiring was not preinstalled. However, it is often difficult to know just how the opposition is exerted, and just what connection, if any, the unions have with code provisions which protect their special interest. A not uncommon practice, for instance, is to resist prefabrication indirectly through a general code requirement such as that all wiring installations be field inspected. If such a provision is literally interpreted, it can prevent the preinstallation of wiring in panels which have both interior and exterior surfaces applied in the factory. Furthermore, some codes require rigid metal conduiting for electrical installations, while others require flexible cable, thus making it impossible for the prefabricator to standardize his installations.

In some areas, according to the prefabricators, union officials have made purposefully unreasonable demands as to the number of skilled workers and the general wage rates to be agreed to by management before production could start, in order to prevent companies from establishing themselves in the house manufacturing field.

No prefabricator reported having trouble in his plant from jurisdictional disputes. There may have been some loss in the potential efficiency of the labor force on occasions when the union contract would not permit a prefabricator to shift workers from one task to another, but no particular instance of this sort was mentioned. General Homes, Inc., which was organized by the CIO, did emphasize the importance of the provision in its contract which permitted any man in the plant to shift to different tasks at different times as the situation might demand. Such a provision might well help to stabilize the factory labor force, and might be particularly important in the field, where flexibility would help to avoid delays and would permit the more efficient use of manpower. This sort of thing has been resisted by the craft unions, but the CIO has strongly supported it. The following letters are an indication of this attitude:

> Since we are an industrial union, we have no difficulty with jurisdictional matters. We apply the same policy to those of our workers engaged in prefabrication of homes as we do to those engaged in the shipbuilding industry.
>
> . . . We do not oppose any device to expand the average productivity of the individual work. However, we do insist the economic result of increased productivity be shared by the worker, as well as by management and the consumer. . . .[12]

[12] John Green, President, Industrial Union of Marine and Shipbuilding Workers of America, in a letter to the Bemis Foundation, June 10, 1947.

Members of this union are engaged in various types of lumber prefabrication.

We are not opposed to labor-saving devices, provided the workers are given a fair share of the added production which can be achieved through the use of such devices. . . .

We are an industrial union in the logging and woodworking industry, and have no internal jurisdictional problems like the building trades craft unions. . . .[13]

Generally speaking, union efforts to restrict plant prefabrication have been minor in extent, and there is evidence that they are becoming steadily even less important.

Labor Relations in the Field

Labor relations of prefabricators in the field are much the same as in the rest of the housebuilding industry. They are, of course, tied up with the prefabricator's marketing system, for when he undertakes to do his own erection, he is likely to use a different form of labor organization from that used by a dealer-erector. In fact, dealer-erectors have handled most of the erection work, and their labor relations have been typical of the small- or medium-sized builder and have involved a number of the same AFL unions at their regular hourly wage rates. On the other hand, General Homes planned to carry out its own erections with CIO labor under the contract mentioned above, an arrangement sought partly out of the fear that AFL labor would refuse to handle the job.

Such a fear was not wholly ill-founded. There have been a number of instances in which AFL unions have opposed the erection of houses fabricated by another AFL organization or by non-union or CIO workers. These date back at least as far as the well-publicized occasion in 1940 when a gang of AFL men attacked a CIO erection crew working on a Gunnison house in East St. Louis, Mo. In the past few years there have been other incidents.

In early 1947, The Green Lumber Company, which had established a CIO shop through a recent election, sold some 200 houses to a builder in Jackson, Miss. When the builder tried to hire AFL men to erect his houses, the business agent refused to allow his men to handle the job. Although both the National Housing Agency and CIO officials appealed to him, the sale had to be canceled.

[13] J. E. Fadling, President, International Woodworkers of America, in a letter to the Bemis Foundation, June 9, 1947.

The Scott Lumber Company, producing Scott Homes, presented a somewhat different case at about the same time. The plant had been organized as a closed shop by the AFL carpenters, but the dealer in Dunkirk, N. Y., ran into strong opposition from local 689 of the carpenters. The local's position was that its members wanted to "build houses, not erect them," that there was plenty of labor and materials locally available to do the job, and that the Scott men, albeit of the same brotherhood, were performing in the factory at Wheeling, W. Va., the work they felt themselves entitled to do.[14]

The Harnischfeger Corporation also ran into trouble in 1947 when it refused to agree to a preferential hiring clause in a contract with the carpenters. The union ordered its members to discontinue erection of the houses and sent letters to its membership advising that neither they nor members of any other building-trades union erect houses which did not bear the label of the United Brotherhood.[15] The carpenters even went so far as to direct their locals and district councils to adopt a by-law that

> No member will use, handle, install or erect any material produced or manufactured from wood not made by members of the United Brotherhood.[16]

It should be noted that the above practices might well be found to be illegal under the secondary boycott provisions of the Taft-Hartley law.[17]

There have been other forms of union obstruction in the field, such as refusal to handle certain prefabricated elements—plumbing, preglazed sash, prehung doors. On occasions there have been delays caused by jurisdictional disputes, most frequently in the case of the erection of a metal house where no clear precedent had been established. The William H. Harman Corporation encountered one such instance; [18] and on occasion there has been a more general and very understandable opposition, such as that voiced by William J. McSorley, General President of the Wood, Wire, and Metal Lathers International Union, AFL:

[14] *Dunkirk Evening Observer,* March 29, 1947, p. 1.

[15] *Labor Relations Reporter,* Vol. 20, no. 51 (October 27, 1947), 395–6.

[16] Minutes of the Meeting of the General Executive Board, Lakeland, Fla., January 16, 1947, *The Carpenter,* LXVII (March 1947), 21.

[17] Labor-Management Relations Act, 1947 (Public Law 101), effective June 23, 1947, Section 8 (b) (4) (A).

[18] *The New York Times,* August 20, 1948, p. 18. Jurisdictional disputes are also illegal under the Taft-Hartley law, but delays can occur without there being a strike and without the case coming to court.

. . . I desire to say . . . that most of the prefabricated houses are designed and built without any lathing and plastering in them. . . . This of course is one of the principal reasons why we are opposed to prefabricated housing, and some of the reasons are contained in the enclosed pamphlet which has been issued by the National Foundation for Lathing and Plastering. . . . We believe that all houses that are erected for the purpose of housing human beings should be lathed and plastered in a proper manner, so as to protect sanitation and health of the inhabitants . . . to be candid, we are not doing anything to promote any program that will have a tendency to put us out of business. . . .[19]

Union opposition in the field has thus been of considerably more concern than that in the shop. But it should be remembered that the few cases of union opposition get more publicity than the many cases of union cooperation. Building is not the only field in which technological change has been resisted, and experience shows that adjustments are made in the course of time. Prefabrication, in one form or another, is a growing reality; the need for housing calls for production in tremendous quantities; and public pressure will call for an end to restrictive practices. In view of these factors it does not seem unreasonably optimistic to summarize that the problem of union opposition is relatively small and appears to be growing smaller.

III. Financing

A. Capitalization

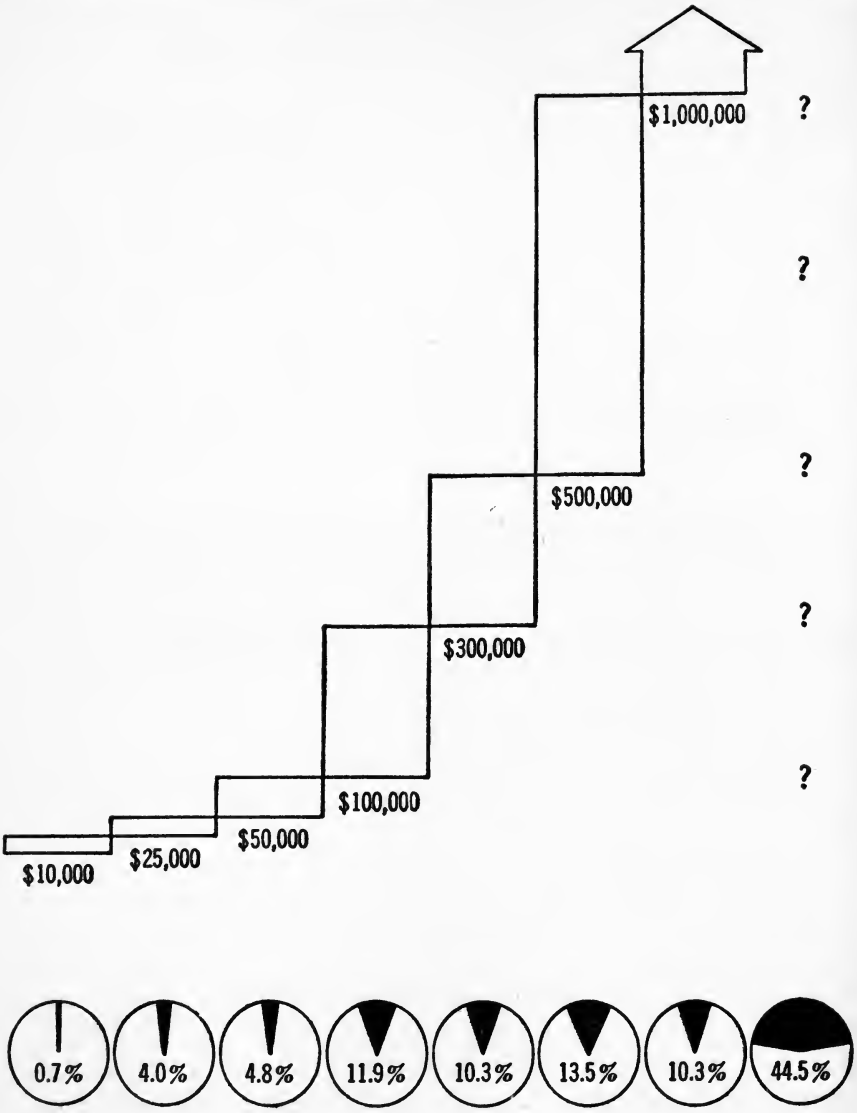
It has frequently been said in the industry that a successful prefabricator requires about $1,000,000 in capitalization. How many of them have reached this figure? Very little information on capital investment in the industry is publicly available. Some manufacturers decline to reveal such figures, and in other cases the capital investment for the production of prefabricated houses is hidden in a figure giving the total capitalization of a firm in which prefabrication is but a subsidiary activity.

Table 1 gives the distribution of capital ratings published in 1947

[19] In a letter to the Bemis Foundation, June 2, 1947.

Table 1

Capital Rating of Prefabricators



126 Firms from Thomas' Register of American Manufacturers, Ed. 38, vol. 1 (December 1947), columns 7863–5.

by one register. It will be noted that information was available for only slightly over half of the companies listed in the register. Those which refused information included several of the largest companies. It should be pointed out, however, that the 13 companies capitalized at over $1,000,000 represented for the most part investments not solely or even primarily in prefabrication. Only a few of the 13 started out as prefabricators and reached the million-dollar class.

PHMI estimated that at the end of 1947 the 80 or so companies that were actively engaged in prefabrication represented a total capital investment of about $60,000,000, with an additional $36,000,000 invested in the industry's dealers.[20] These figures, too, would indicate that there may be an appreciable number of firms in the industry capitalized in excess of $1,000,000.

B. Sources of Investment Capital

Only three prefabricators are known to have raised their capital through public stock subscription: Anchorage Homes, Inc., General Panel Corporation of New York, and William H. Harman Corporation. In the majority of cases, capital has been obtained privately, usually through individuals, sometimes through parent organizations, but seldom through financial institutions. It is more or less to be expected in an industry such as this where risks have been high that the banks would be of only minor assistance. Only 14 companies indicated that they had gone to banks for long-term capital loans, while 10 companies reported that they had experienced difficulties with banks; most companies reported no dealings at all with banks in connection with long-term capital requirements.

A large segment of the industry has been financed by parent corporations of one type or another. Among the prefabricators active at the time of our survey, many owed either their original formation or much of their capitalization to large industrial enterprises. Partly because of this parenthood, these were some of the best-known names: Gunnison Homes (United States Steel Corporation); Stran-Steel Arch Rib Homes (Great Lakes Steel Corporation); Wingfoot Homes (Goodyear Tire & Rubber Co.); Butler Homes (Butler Manufacturing Company); Kaiser Community Homes (Henry J. Kaiser); Thermo-namel Houses (Higgins Industries); Lustron (Chicago Vitreous

[20] Austin Drewry, President, PHMI, Opening Address at Winter Meeting, December 15, 1947.

Enamel Product Co.); and P & H Homes (Harnischfeger Corporation). Such companies also had some of the largest and best-equipped plants in the industry.

Other prefabricators have been financed in large part by large contractors and builders, as, for example, Johnson Quality Homes, Inc., by John A. Johnson Contracting Corporation, and Kaiser Community Homes by Fritz B. Burns. Still other companies have been financed by parent lumber or plywood organizations, such as Prenco by C. D. Johnson Lumber Corporation, Hayward Homes by Hayward Lumber and Investment Co., and General Timber Service by Weyerhaeuser Timber Co.[21]

Some companies have financed part of their operations through a licensing system under which they receive royalties from licensee manufacturers operating in various localities. Ivon R. Ford, Inc., had some nine licensees at the time of the survey, and American Houses, Inc., had six, in addition to its own three plants.[22]

There have been numerous enterprises which failed to get into production for lack of venture capital. While this might be true of any enterprise, it is probably harder to attract venture capital to new methods of housebuilding than into most other fields, and perhaps rightly so. Part of the explanation lies in the mass of obstacles which the innovator in this field faces in the way of restrictive practices, codes, consumer resistance to change, and so forth—a list which has been enumerated many times. Another part lies in the extent to which aspects of building permeate a vast range of institutions: family, neighborhood, city government, public utilities, organized labor, big business, real estate, financial institutions. Whatever the causes, and there are more than a few, housebuilding has been dubbed "the industry capitalism forgot" [23] and has been singled out frequently as that industry most in need of the sort of revolution that has characterized the history of capitalism. Raising venture money has not been made easier by a number of well-publicized failures in prefabrication, especially recently, even though an analysis of the proposed patterns of operations would have revealed from

[21] Very indirectly, several other companies were related to large capital. Many Baldwin Locomotive officers were interested in Harman; Consolidated Vultee decided not to back a house, but some of its officers were associated with Southern California Homes; and the Ibec house is a venture of Nelson Rockefeller. The ultimate decision of Beech Aircraft not to produce for Fuller was a major blow to Fuller Houses.

[22] The license arrangement was perhaps most extensively used just before the war by Precision-Built Homes Corporation which at that time had 67 licensees.

[23] *Fortune,* XXXVI (August 1947), 61.

the start that failure was very likely in most cases. Consequently the companies having the most radical ideas and generally involving the greatest risks have had even more difficulty with financing than might be expected. Perhaps the most spectacular case of this sort was the Fuller house, an enterprise attended by much notoriety because of its boldness and novelty, but one which never got under way because of failure to attract enough risk capital.[24] Other somewhat more conservative companies have also had to struggle to get private financing—Lustron, General Panel Corporation of California, Reliance Homes, and Southern California Homes are examples, each one of which proposed major innovations.

One result of this situation has been a debate, inside the industry and out, and often quite heated, as to whether a very large initial investment is a necessary condition for success in prefabrication and if so whether the government should take an active part by securing, or even making, such an investment. On one side have been the older and more conventional members of the industry, usually working in wood, who have held that the industry would grow of itself if only given the chance, that no huge investments were needed, particularly if they had to be government sponsored, and that no special favors were required, but only a minimum of government regulation of sufficient stability to make planning by business possible. On the other side have been many of the newer and more unconventional companies which have argued that thus far prefabrication has not made good on its promise of cost reduction, that revolution, not evolution, is necessary, that houses can be mass produced at really low costs only by an enterprise which represents a complete discontinuity with the past in both the nature and the scale of its operations, and that in a housing emergency the government should take an active part in encouraging such ventures. By and large these divergent opinions were represented respectively by the Prefabricated Home Manufacturers' Institute and the National Association of Housing Manufacturers, but were by no means confined to them. The latter philosophy lay behind the Wyatt program and in the somewhat less active role the government has played since the Veterans' Emergency Housing Program ended. In any case, the government has become an important factor in the financing of the industry in recent years.

The sale or lease of surplus war plants to prefabricators is one direct means by which the government assisted certain firms in estab-

[24] See "What became of the Fuller house," *Fortune,* XXXVII (May 1948), 168.

lishing themselves. The Housing Expediter was empowered by the Veterans' Emergency Housing Act [25] to direct that certain surplus production facilities be disposed of for use in the manufacture of housing. Nine prefabricators are known to have acquired plant facilities in this way, several of the factories being very excellent buildings once used for aircraft production.[26]

More important to the capitalization of the industry have been the three financial mechanisms involved in the government program: loans, market guarantees, and the insurance of loans made by private institutions.[27] The last two are concerned more with working capital than investment capital and are discussed later in the section on credit. The loan program developed out of a background which had seen the wide use of government powers in times of national defense and war, and out of legislation that extended some of these powers into a time of drastic housing emergency. Under the provisions of the Veterans' Emergency Housing Act the Housing Expediter was given the authority to direct the RFC to make loans to prefabricators. Early in the history of this program there were a number of disputes between the RFC, which declined to make loans that it considered unsound, and the Office of the Housing Expediter, which held that the risks were not as great as imagined and that in any event the housing emergency justified such risks. The nature and outcome of these disputes were partially responsible for Wyatt's resignation as Housing Expediter; [28] however, the RFC had made 20 OHE-sponsored loans to prefabricators by June 1, 1948. These loans totaled $38,290,000, and, as of that date, disbursements had been made to 12 of the companies in the total amount of $9,565,000.[29]

[25] Public Law 388, 79th Congress, approved May 22, 1946.

[26] For instance, Lustron obtained part of the Curtiss-Wright plant in Columbus, O., and General Panel part of the Lockheed plant in Burbank, Calif. Source: War Assets Administration, Office of Real Property Disposal, June 1947.

[27] It should also be remembered that another type of government assistance to prefabricators was the priorities and allocations program through which, at a time of critical postwar shortages, materials were channeled to them.

[28] December 4, 1946.

[29] Source: RFC records to June 1, 1948, reviewed by the Bemis Foundation. Of the 8 companies to which no disbursements had been made:

1 loan was outstanding.

7 loans had been canceled. Of these:

4 companies abandoned plans.

1 company obtained financing from other sources.

1 company failed to raise necessary equity.

1 company withdrew application.

The largest single loan was the initial loan of $15,500,000 to the Lustron Corporation, made only after a considerable period during which the matter was extensively debated. At the time that the formation of Lustron was announced $840,000 in private capital had been raised.[30] The RFC subsequently made loans to Lustron which eventually more than doubled the initial amount, by its own decision and not under direction from the OHE, which was later functioning in a liquidating capacity only. Thus the most heavily capitalized enterprise in the industry, one several times bigger than the next largest firm, was almost entirely financed by the government.

The principle of government loans to prefabricators was extended by the Housing Act of 1948, passed by the Special Session of the 80th Congress.[31] The Act authorized the RFC to make loans for the production of prefabricated houses or components or for large-scale site construction, but if such loans were used for the purchase of equipment, plant, or machinery the loan was not to exceed 75% of its purchase price. Such loans were not to exceed $50,000,000 outstanding at any one time, and were not to be made if financing was otherwise available on reasonable terms.

C. Credit

According to some, the most important and least understood problem facing prefabricators is that of credit. While this may be an extreme point of view, it is nonetheless true that obtaining credit has been a crucial question for many firms, particularly in the steady and continuous flow that may be required throughout every phase of the housebuilding process—by the prefabricator to pay for raw materials, labor, and other costs of production; by the dealer to pay the prefabricator for the factory package; and by the homebuyer to pay the dealer for the completed house. In the production process the sums involved tend to be very large, and many prefabricators cannot finance their operations without resorting to working capital loans of one sort or another.

The total investment of a prefabricator who undertakes to produce 100 house packages at $4,000 per package is $400,000. If these houses cannot be sold to a dealer for cash, the prefabricator's

[30] *The New York Times*, November 1, 1947, p. 22.
[31] Public Law 901, approved August 10, 1948.

capital will be tied up in them, and he will soon have to cease production. Similarly, the dealer cannot use his capital again until the customer pays him for the finished house. It is not enough that financing be available at all stages; it must be available without delay, so that the flow of funds will proceed at a pace with the flow of materials and fabricated products. The last two stages, relating to dealer credit and consumer credit, are discussed in the chapter on marketing, leaving only the credit which is extended to the prefabricator for working capital loans to be treated here, although all three are interrelated.

First of all, it should be pointed out that not all prefabricators have had a problem in obtaining working capital. Many companies have had no need to borrow for this purpose, either because they have steadily accumulated sufficient capital for their scale of operations, or because they have large parent concerns which make such capital available to them. Other firms were able to obtain credit from their materials suppliers, especially in cases where the prefabricator had previously established contacts with them in some other type of building enterprise. Most of the older members of the industry had lines of credit with the banks. Thus it was primarily the youngest firms, and particularly those which planned to commence operations on a large scale, that encountered difficulty. Not infrequently these were regarded as risky ventures, and the problem was therefore to earn the confidence of the banks. The bankers expected these firms to prove themselves through successful operations over a period of time, but how were they to get started?

One device which was designed in part to meet this problem was the guaranteed market contract, under which it was hoped to reduce the risk attending a new prefabrication venture by having the government act in an underwriting capacity. The Veterans' Emergency Housing Act authorized the RFC to guarantee markets for prefabricated houses to the extent found necessary by the Housing Expediter in order to assure a sufficient supply for the Veterans' Emergency Housing Program, but the number of houses covered by the outstanding guarantees was at no time to exceed 200,000, nor was the net loss to the government to exceed 5% of the total guarantee undertaken. A number of criteria were set forth: guarantees would be of temporary duration, would be pointed towards low-cost products, would not cut into the market for conventional houses, and would be awarded only after rigid tests on the house and a demonstration of ability to perform by the prospective producer. In brief, the contracts specified a production schedule and provided that if

the prefabricator was unable to sell what he had manufactured, the units would be purchased, subject to certain conditions, by the RFC. The manufacturer was obligated to repurchase the units from the RFC before selling any more houses of the same or equivalent type. Thus it should be noted that the guaranteed market contract did not provide a market into which could be continuously poured the output of a prefabricator; it did not offer an opportunity for operational improvements by absorbing the output during a period in which changes in design, production, or distribution technique might be made. Once a prefabricator tendered houses to the government, he was essentially forced to halt production. The contracts did serve as collateral, however, by certifying that the government was ready to buy what could not be sold elsewhere, and thus they enabled some companies to obtain loans for much needed capital.

Of 74 companies which applied for market guarantees, 20 received contracts, all terminating December 31, 1947.[32] The contracts guaranteed the market for 61,696 units out of a total original scheduled production of 90,596, and involved a total liability of $195,833,708.[33] Actually, however, fewer than 3,000 houses[34] were produced under these contracts, a disappointingly small total which reflects the fact that many of the companies did not get into production before their contracts were terminated or, in some cases, canceled by mutual consent.[35] The net loss to the government was about $3,000,000,[36] about 1½% of the total liability and well below the specified limit, but in light of the production that resulted, the program can hardly be called anything but a failure. A redeeming point was its assist-

[32] The balance of 54 did not receive contracts for various reasons, including the following:

(1) Not enough experience.
(2) Insufficient equity to qualify for RFC loan—therefore had no funds.
(3) House not technically acceptable.
(4) Design too costly, used too much critical material.
(5) Unable to obtain plant or equipment.
(6) Showed only initial interest—did not follow up with necessary papers.

[33] Source: OHE official records, reviewed June 1, 1948, by the Bemis Foundation.

[34] Source: *loc. cit.*

[35] The magazine *Business Week* (December 11, 1948), p. 25, covering the marketing and finance problems of prefabricators, stated that only six out of 32 companies which secured guaranteed market contracts or loan agreements through RFC were still turning out houses.

[36] Source: OHE estimate, given to the Bemis Foundation, June 1, 1948.

ance in the formation of several enterprises which may have a stimulating influence on the development of the industry.

The underwriting of loans was the third of the financial mechanisms by which the government sought to help prefabricators obtain capital. This program was initiated on July 1, 1947, when Congress, by amendment of the National Housing Act (Section 609), provided for federal insurance of working capital loans. These could be for as much as 90% of the necessary current cost of manufacturing the house (package), exclusive of profit. In principle, this extension of FHA operations had its counterpart in the FHA Title VI program for conventional construction under which were insured the construction loans used in financing homebuilding at the site. Since construction loans for conventional building were being insured only if the permanent financing for the home had been arranged, a production loan under Section 609 was to be insured only if the prefabricator submitted binding purchase contracts as collateral evidence of sale and ability to pay for houses manufactured with the proceeds of the loan.

By April 30, 1948, when the original form of the Title VI program expired, 24 applications for Section 609 loans had been received. Only one company, however (Housemart, Inc.), had actually obtained an insured loan, and this was for the production of 194 houses. Why, it may be asked, were so few houses financed under this program during the 10 months it was in effect? Part of the answer to this question lies in the difficulty of judging the technical merits of an applicant's product by a review of plans and specifications, and by examining and testing a hand-made prototype not produced under conditions to be expected in full production. Part of the answer lies in the length of time required to investigate all those other aspects of the applicant's business operations which the FHA considered it necessary to investigate—the borrower's plant facilities, financial condition, manufacturing costs, marketing plans, etc. But, to the largest extent, the answer involves the "binding purchase contract" which the prefabricator was required to show before he could obtain a loan. Section 609 did not define such a contract in specific terms, and certain applicants for loans were led to criticize the FHA's interpretation of the phrase, which was cautious and conservative. In effect, the FHA did not wish to be involved in insuring the marketability of the houses; it wished to make certain that they were not being produced for an unknown market. No loan was approved for insurance unless the dealer-erector involved in the purchase contract could show that he had the necessary cash in

hand or arranged for, which meant that he must have arranged the permanent financing for the houses before the fabrication process could start. Many housing manufacturers held that this was an unrealistic requirement, that it was not practicable to make these financing arrangements so far in advance of delivery of the houses.

> The housing manufacturers feel that FHA will be fully protected if *by the time the houses are to be delivered* under a purchase contract, the purchaser is required to have the cash for payment on delivery, or to have financing arranged which assures the payment of the balance due under the contract.[37]

It is clear that one issue involved here is the extent and nature of risk contemplated by Congress when it enacted Section 609. But whatever the pros and cons of FHA policies in regard to this program, it remains a fact that, in its original form, it fell far short of its objectives, and changes were introduced into Section 609 when it was reenacted along with other elements of the FHA's Title VI program in the Housing Act of 1948.[38]

In this new form Section 609 authorized insurance of loans for the manufacture of prefabricated house packages on the basis of contracts (for the purchase of these packages) which provide for payment of the purchase price within 30 days after delivery of the houses, or payment of 20% of the purchase price on or before delivery if the institution making the loan to the manufacturer accepts and discounts a promissory note for the unpaid balance payable within 180 days from the delivery date. In addition to insuring loans to finance the production of house packages, the new Section included provisions for short-term financing of dealer-erectors by authorizing the FHA to insure the lending institution against losses sustained in accepting and discounting promissory notes of purchasers representing the unpaid purchase price of the packages. These notes could not exceed 80% of the purchase price, nor could they have a maturity in excess of 180 days.

A further feature of great importance was also added: the manufacturer was permitted to substitute new purchase contracts as security on the loan in place of contracts which had been performed. This, in effect, made the principal amount of the loan a revolving fund for

[37] (Our italics.) Statement by Nathan Wendell, Vice-President of the National Association of Housing Manufacturers and Vice-President of General Panel Corporation of California, given before the Joint Committee on Housing, 80th Congress, 1st Session (*Study and Investigation of Housing*, Part 5, p. 5,062).

[38] Public Law 901, approved August 10, 1948.

financing the production of additional houses above the number stated in the original loan agreement.

IV. Public Relations

Public relations has been an important problem of the prefabricator for more than a decade. Before the war it was principally a matter of overcoming consumer prejudice against novelty in the design of the house. Since the war it has more frequently been a question of correcting the impression that prefabricated houses are temporary dwellings which are structurally inadequate.

Public attitudes have exerted their influence not only in consumer resistance, but also in active and organized opposition to the erection of prefabricated houses in certain communities. A typical example was the trouble encountered in 1947 when an attempt was made to erect in Natick, Mass., a suburb of Boston, a house produced by Winner Manufacturing Company, Inc., under license from Shelter Industries, Inc. The house was of modern design and stressed skin plywood construction. A building permit had been granted and erection was under way when a group of neighbors, fearing that their property values would be seriously endangered, brought pressure on the building inspector to revoke the permit which he had already issued. After appeal to a special emergency board which had been set up in Massachusetts, and a consideration of this appeal mechanism by the courts, the permit was finally granted. Such were the difficulties and the character of public opinion, however, that the company later turned its attention to other areas with a modified design.

One indication of the importance of public relations to the prefabricator is the considerable number of firms, 18, which our survey found using public relations agencies or counselors. There has been, of course, a great deal of free publicity given to prefabricators in all types of communication media, and this is, perhaps more than anything else, a reflection of the keen interest of the public in anything which might help solve the housing problem. Much of this publicity has been the wildest sort of fantasy, however, and much more has

been entirely premature; it has probably done the industry more harm than good.

Because some unquestionably poor houses have been produced by prefabricators and because some of the most widely publicized ventures have come to naught, many firms have sought to distinguish themselves from the rest of the field by means of carefully directed advertising campaigns. Some do cooperative advertising with their dealers, splitting the cost, so that they can control the content and quality of the ads. Others seek to avoid identification with prefabrication entirely by disclaiming any resemblance to all that has gone by that name, by designing and erecting their houses so that they cannot be distinguished from the conventional product, or by employing such terms as "prebuilt," "pre-engineered," "manufactured homes." There is, in fact, strong support for the abandonment of the term "prefabrication" in favor of "house manufacturing" or "home manufacturing." The use of the seal of the Prefabricated Home Manufacturers' Institute is another means by which some companies have sought to create a reputation of soundness for their products. And a very influential factor in establishing a prefabricator's reputation for quality is the approval of his house for mortgage insurance by the FHA.

Mass distribution through brand-name selling is one of the important potential advantages offered by prefabrication. This is recognized in varying degrees by most prefabricators and has been heavily stressed by a few. As the housing market has changed, and as the scope of the marketing problem has come to be recognized in the past few years, there has been increasing emphasis on the selling effort required and on the advertising that must be a part of the distribution pattern. Most firms engage in some form of advertising in addition to their descriptive brochures, usually in local newspapers and in trade journals; a few firms, like Lustron, Adirondack Log Cabin, and National Homes, have also done magazine advertising on a nationwide basis. But it is probably a fair generalization that the development of brand-name selling through advertising has not yet been carried beyond the initial stages by the vast majority of prefabricators.

V. Trade Associations

There are at present two trade associations functioning in the industry, the Prefabricated Home Manufacturers' Institute [39] and the National Association of Housing Manufacturers.[40] These differ quite markedly in their membership, policies, and activities.

A. Prefabricated Home Manufacturers' Institute

The need for an association of prefabricators in 1942 led a half-dozen of the industry's pioneers to form the Prefabricated Home Manufacturers' Association. In 1943 the Association renamed itself an Institute, there being 12 charter members. By January 1946 membership included 30 companies, and in the boom days of early 1947 it reached a peak of 67. In mid-1948 membership was stabilizing at 46. While membership is not limited to users of specific materials, PHMI is largely comprised of those firms which work in wood (including plywood), and which have approached most aspects of prefabrication with what might best be called a conservative attitude. Among the companies which have been most active in the organization are Gunnison Homes, Inc., National Homes Corporation, Pease Woodwork Company, Inc., American Houses, Inc., Southern Mill & Manufacturing Co., The Green Lumber Company, Houston Ready-Cut House Co., Crawford Corporation, Ivon R. Ford, Inc., Page and Hill Co., Harnischfeger Corporation, and Johnson Quality Homes, Inc. The PHMI staff includes a manager, a public relations man, and a statistician and cost accountant. Harry H. Steidle, who heads the staff, was for five years Washington representative for the Douglas Fir Plywood Association and active in other trade association work before joining PHMI. Some years previously, he was Assistant Chief

[39] 908 20th St., N.W., Washington, D. C.

[40] 1028 Connecticut Ave., N.W., Washington, D. C.

Although the Douglas Fir Plywood Association is not, properly speaking, in the industry, it should be mentioned here because of its promotional activities in behalf of prefabrication since 1938. The Association regards prefabricated houses as an important long-run market for plywood and has published several booklets to further this type of construction.

of the Division of Trade Standards in the National Bureau of Standards.

PHMI maintains about a dozen standing committees, the most important of which deal with industry promotion, marketing, employer-employee relations, technical problems, accounting and statistics, materials, and government relations. The accounting and statistics committee has made some progress towards having a uniform cost-accounting system adopted by member companies, while the technical committee has developed a set of performance standards for prefabricated houses which was published as Commercial Standard 125–45 by the National Bureau of Standards.[41] In addition, the technical committee has worked with building-code officials in various sections of the country in order to reduce the code conflicts facing the industry.

In its public relations role, PHMI furnishes information to the press and interested individuals and represents the membership at builders' conventions and similar meetings. The Institute's advertising campaign, with its use of a seal and its emphasis on quality standards, has been an important part of this program. Members receive a weekly newsletter which presents an excellent summary of housing activity and pertinent legislation, occasional generalized reports on the operations of member companies, and other news of interest. Conventions are held several times a year and provide an opportunity for the exchange of information.

Naturally, an important function of the Washington office has been to represent the interests of member companies and, when appropriate, the industry as a whole, in the various federal agencies connected with housing and before committees of Congress. During the Veterans' Emergency Housing Program, when the government allocated materials and controlled prices, this function was particularly important. The attitude of PHMI towards a government program for prefabricators, however, has rather consistently opposed special aids. The organization was against many elements of the Wyatt program on the grounds that they would bring into existence many get-rich-quick firms which could not last but which would impair the industry's reputation and credit standing. This attitude has been strengthened recently with the failure of inexperienced government-financed firms, which resulted in the general loss of confidence in the industry in some banking circles. While PHMI has opposed guaranteed markets, RFC loans, and the Housing Act of 1949, it has fought for

[41] A second edition, Commercial Standard CS125–47, was published in November 1947.

liberal mortgage financing under Title VI and for stability and consistency in federal housing legislation so that long-range plans could be made by those in the business of providing homes.

B. National Association of Housing Manufacturers

Founded in February 1947, NAHM from the start emphasized the use of modern methods and improved building materials and techniques. Its efforts have been largely directed towards the new firms in the industry which have been using unconventional materials and new designs. The organization was not designed to serve as a public relations front, and so it has avoided publicity as much as possible, although it has testified at hearings.

The primary purpose has been to help secure the necessary legislation and regulations to make available the government assistance which these companies require, including loans for working capital and the marketing of houses, priorities and allocations of materials, and mortgage financing for the completed houses. In this connection, NAHM representatives have testified before various Congressional committees as well as committees and agencies within the executive branch of the government, such as, for example, the Office of Industry Cooperation of the Department of Commerce, where the voluntary allocations program has been administered. NAHM has been of considerable influence in securing the legislation and assistance required by the industry, but in general it has remained in the background.

The membership has varied from time to time, and a number of non-member companies have participated in the meetings. Attending these have been as many as 15–20 companies, among which were a few producers of new-type housing materials. Among the companies which have been most active in the Association have been Lustron, whose President, Carl Strandlund, was the initiating force behind the Association and has been its President from the beginning; General Panel, whose President, Abel Wohlstetter, is the Vice-President of the Association; and Reliance, whose President, Harry Nagin, is also a Vice-President of the Association. Counsel is David L. Krooth, former General Counsel of the National Housing Agency and of the Housing Expediter.

NAHM thinks of itself as representing the producers of industrialized or machine-made housing, rather than the prefabricators, who,

it holds, are for the most part still working in conventional materials in the conventionally inefficient way. Its policies and actions reflect the problems of some of the youngest firms in the industry who believe in new materials and methods and have built up high production capacities. If prefabrication is to mean revolution, these are the revolutionaries, and their Association is well versed in the new skills of securing programs of government assistance for enterprises likely to be of public benefit.

Part II.

Chapter 7

DESIGN

I. Introduction

Prefabricators of houses in the United States during the period of study by no means pursued the same goals. Their diversity of interests is reflected in their approach to design. To some this term meant structural engineering; to others it meant production engineering; to a few it meant architecture; and to many it meant sales appeal. The term properly includes all these aspects, and many others, for a decision made in any part of the long operational channel which leads from raw materials to completed houses may have an important effect on the design of the house itself.

Considering the term as broadly as this, one might with some justification say that this entire book is a discussion of factors which should influence design. As used in this chapter, however, the word means something narrower and more concrete. Described here in some detail are the different products which were made by the companies studied, with some reference to the techniques by which they were made. This, then, is design, in the terms of plans and specifications, and as defined by production systems.

That the subject does not lend itself to simple treatment can be illustrated on the one hand by the millions of dollars spent by Lustron before even starting production, and on the other hand by the small company which, in answer to our request for information, reported that it had been so busy getting into production that it had had no time to make plans and specifications.

In large part, differences in design stemmed from differences in basic approach to prefabrication. The type of market sought, the house planned for that market, the scheme for the production of that house—all these things varied tremendously, and it would be a fascinating study to analyze the reasons of background, experience, intuition, and prejudice which could lead to such differences among producers in the same general field.

One generalization may safely be made, however: the fundamental decisions upon which these different schemes were based were rarely the result of a thorough investigation of the whole problem; they did not come as the result of careful research. Whether research had a separate existence or was in effect just another of the responsibilities of the top management, its scope seems to have been largely

limited to the improvement of detail, the saving of material, and the speeding of operations.

The average prefabricator seemed to think a great deal harder about the details of his design after it had been adopted and was going into the production or even the marketing phase than he had in the first place about the broad principles upon which the design was based. This is perhaps understandable, since time, energy, and money for broad analysis are often very limited once operations are under way, while in the early stages of organization and design the problems of financing and of creating a production and distribution system tend to seem very small and remote. When the realization comes that the first step in the pattern of operations should have been altered in order better to perform the last, the die has been cast.

In many cases, the prefabricators set out to do little more than produce a conventional wood frame house by somewhat different methods and for about the same price, the new methods being undertaken solely from the point of view of reducing production costs. Design efforts were concentrated on the selection of materials, of fabrication procedures, and of packaging, shipping, and erection techniques. In time, and with a large enough volume of business, such producers might hope to sell a better house for less money. At present they would say more often that they are selling a better value for the same money.

A larger group have set out to simplify the design as well as the construction of this conventional house, so that it might be easier to build, ship, and erect, and at least as good. Frequently these prefabricators have attempted to improve the space arrangements, the details, the appearance, and the general architectural design of the houses they build. But they have not usually moved in this direction beyond their ideas of current public acceptance, or perhaps beyond their interpretation of the ideas of public acceptance currently held by mortgage bankers. The industry well knows that it sells its houses to bankers rather than to purchasers; broad circulation is given to reports of companies which have brought out houses of radically simplified or of purportedly modern design, only to fail or lose money as a result. There have been such cases, and some justification exists for the feeling that good modern design does not carry with it the strong sales appeal that the predictions of the war years had attributed to it. In several cases [1] prefabricators were forced to stop production on models which had been given much favorable

[1] For example: Shelter Industries, Green's Ready-Built.

comment in architectural magazines in favor of models of far more conventional appearance.

Among the prefabricators there were a few, as there have been all through the years, who approached the problem with a real determination to seek out the basic facts of housing design and to strike out beyond the limitations of conventional methods. Of these pioneers, some strove for what has been called in England "austere" shelter: smaller houses, simpler in plan and construction, of less expensive materials, and more highly organized in their various functions than the conventional house ordinarily thought of as "minimum." These schemes were based upon a desire to find some sort of decent shelter which might be made available to a wide range of low-income families. There were also schemes based upon emergency conditions and designed for temporary or at most periodic use; schemes of this sort were often designed for use in war production areas. Still others resulted from the attempt to achieve a high degree of mobility, with the consequent desire to cut the weight and bulk to be moved (a few turned their attention frankly to the problems of the house trailer), or from the desire to capitalize on the possibilities of obtaining a high degree of elasticity by means of a very standardized production system.

Some of these departures from the conventional were very radical indeed, based on the theory that true mass production will eventually have to make use of metals rather than wood, aimed at the exploitation of some new use of metals or other materials, or guided by the determined effort to rationalize the whole structural theory of mass production of houses.

The most familiar example of such a pioneering approach was Buckminster Fuller's hemispherical aluminum house, a structure of true stressed skin design making extensive use of metals in tension rather than in compression, although as a production, erection, and sales proposition it was perhaps foredoomed to failure. From an entirely different point of view unconventional design principles were explored through the work of Wallace Neff, whose gunite structures were built up over balloon forms, and of R. G. LeTourneau, whose gigantic traveling forms were capable of carrying complete concrete houses, poured in one operation, and placing them at the selected site.

The similarity to conventional construction stood out more than any degree of innovation, however. This is not necessarily a criticism, for construction has moved forward, and the conventional house of

today has many features of design and construction which differ from those of the conventional house of only a few years ago.

II. Classification of Prefabrication Systems

Methods of classifying prefabricated houses are as varied as the purposes of those making the classifications. The general public is probably most interested in size and price, but these are also the most variable of characteristics and the least suited to broad analysis. Architectural style is perhaps the next most popular basis of classification, and it will be discussed briefly later; attention will also be devoted to classification by structural system. First of all, however, attention is given to classification by the principal materials used in the house, since this offers the opportunity for a brief description of the characteristic qualities of the various materials for prefabrication purposes and thus provides a general background for the systematic analysis which follows.

A. By Materials

Materials have been chosen for ease of procurement and use, for adaptability to the prefabricator's pattern of operations, and for technical satisfaction of normal performance requirements, the special qualities required in materials by most prefabricators being light weight, strength, wearing quality, adaptability to normal fabrication and transportation methods, and as low cost as possible.

1. Wood Lumber and Plywood

By far the largest group of prefabricators at the time of the survey used wood as the principal structural material. Of the companies studied, 92 used wood, and, of these, 61 used plywood.

The development of plywood construction systems by the U. S. Forest Products Laboratory and others had, in fact, a large influence on the growth of prefabrication as a whole. The material is very light and strong, is extremely stiff, has some insulation value, comes in large sheets readily adapted to mass-production uses, has fairly good dimensional stability, and is reasonably durable and low in cost. It can be used to combine several different functions; for example, a single sheet can be both surface and structural sheathing on the outside, or both surface and wallboard on the inside.

Nearly all the companies using plywood used Douglas Fir rotary-cut veneer, although a few used other types, such as gumwood and yellow pine plywood, edge-grain fir panels for flooring, or oak plywood for flooring. Some of the problems involved in using this material are discussed in Chapter 9. Its steady rise in cost has been discouraging to many manufacturers, but most of them felt that it was the best material available for their needs.

Wood lumber, traditional material for domestic construction in most parts of the United States, enjoyed great popularity among the prefabricators, particularly because of its wide public acceptance and the long experience of builders in making houses of it. From the point of view of design, members fabricated from wood generally have the necessary strength, rigidity, and thermal-insulation value at a suitable cost, although the material offers certain complications in the factory (discussed in Chapter 9). Wood lumber, in other than shop grades, was in fairly good supply at the time of the survey, and its initial cost was low compared to that of other materials. Its character as a handicraft material was actually desirable in the opinion of most prefabricators, who dealt with a few houses at a time rather than mass production, and who had frequent occasion to change shapes and sizes to fit evolving needs.[2]

2. Steel

Steel is the basic manufacturing material of United States industry, and there have been many attempts to use it for the manufacture of low-cost housing. Of the companies in the survey, 13 used steel as a

[2] For a very complete discussion of the use of wood and plywood for this purpose, see *Manual on Wood Construction for Prefabricated Houses,* prepared by the Forest Products Laboratory in collaboration with HHFA (Washington, 1947).

basic material in their structure. Of these, three used steel in combination with wood and three in combination with aluminum.

In housing design, steel has many disadvantages to counter its known advantages. Its thermal conductivity is more than 300 times that of wood so that careful attention must be paid to problems of heat loss and condensation. Its tendency to rust means that it must be carefully protected from contact with oxidizing atmospheres, and this raises costs. Its uniformity and strength are very high but difficult to exploit to the fullest degree, so that much steel is often wasted in overdesign. Occasionally, there is further waste in pointless imitation of wood design. Further, its use requires special attention to problems of sound transmission and reflection. Nevertheless the cost of steel and its adaptability to manufacturing techniques will doubtless continue to appeal to designers. In special forms, such as the porcelain enameled steel used by Higgins and Lustron, it may have a new order of general sales appeal as well as improved physical properties.

In the last two decades, despite a great deal of experimentation with different steel designs in this country, there has not been so wide an experience with actual fabrication and use as in England. Recently, however, there is an increasing tendency among even the more conventional prefabricators to use steel for members in horizontal position which carry loads over fairly large spans, such as floor joists.

3. Aluminum

Of the companies in the survey, 10 made use of aluminum as a major structural material, either as framing or as exterior structural covering. Many others were interested in the possibilities of its use because the expansion of aluminum production facilities during the war period had given hope of abundant supply, particularly of sheet aluminum such as is used in aircraft, and of a lowering of price.

Aluminum has some of the disadvantages of steel, including a particularly high thermal conductivity, but it has certain advantages for housing purposes, including a positive value as reflective insulation and a strong resistance to serious corrosion under normal atmospheric conditions. Although it can be welded only with some difficulty and must be formed with careful attention to its properties, aluminum is suited to many industrial techniques. More expensive than steel,

pound for pound, it is often competitive with that metal when properly designed, processed, put in place, and protected. Care must be taken in the use of aluminum, however, because electrolytic action takes place between it and steel, and because it is subject to attack by free lime in concrete.

As in the case of steel, although there has been a great deal of experimentation in the United States with aluminum construction, and although the aluminum manufacturers are marketing an increasing number of products for use in houses, the largest production experience with aluminum houses has been in England, where the aircraft industry has been producing well-designed units in quantity since the war.

4. Concrete

Generally speaking, prefabricators consider wet-process materials unsuited to mass-production methods, although there are exceptions, as when such special fabrication machines as the Tournalayer are used, in which case the production interest centers in the machine rather than the houses. Yet, of the companies in the survey, 10 used concrete as a major structural material, eight of these using it in the form of precast concrete slabs. Concrete may have distinct advantage over other materials in original materials cost, but its disadvantages of weight, bulk, and frangibility have limited its use primarily to group erections close to the production point of the slabs. In this country, where wood and steel are still available at relatively low cost, concrete construction has been by no means so widely studied and so carefully utilized as in countries where other materials are almost out of the question for housing.

In recent years lightweight aggregates and foamed concretes have become increasingly important, since they lighten the slabs and improve the otherwise poor thermal-insulation qualities of concrete. A great deal of effort has also been expended to improve physical qualities and speed up the production cycle by steam curing and vacuum processes, and to reduce the expense of mixing, pouring, and forming equipment in relation to the quantity of production achieved. Prestressed concrete shows promise of achieving two or three times the strength of ordinary concrete with the same weight of material and is being more generally used in the construction industry, but all these

processes are still relatively strange to the single-family-house market, with which the prefabricators were almost exclusively concerned.

5. Plastics

The literal meaning of this word is broad enough to include many substances not ordinarily thought of as plastics, such as concrete, brick, and glass. Plastics in the common sense of the word, however, were used as a major structural material by none of the companies surveyed. In part, this was undoubtedly the result of the high cost of most plastics, now and in the foreseeable future, but there is also evidence that the structural properties of most plastics are inferior to those of wood, steel, concrete, and aluminum.

The comparatively low modulus of elasticity of most plastics, in conjunction with fairly high strength, also means that it would be inefficient to use such a material as a structural member designed to carry loads, since the amount of plastic required from the point of view of strength would be far less than the amount necessary to prevent objectionable deformation due to low modulus of elasticity.

Laminated phenolics, the most seriously considered of the plastics as a structural material, have three or four times greater strength in compression than in tension, which makes it difficult to justify using so expensive a material in tension as a working skin. Where a material is used as compression, or load-bearing, members, the aim of the designer usually is to produce members as light and as stiff as possible. Yet, to achieve the same resistance to deflection in a laminated phenolic as in a steel compression member, nearly two and a half times the weight of the steel would be required.

The plastics industry is at work on these problems, and such new materials as glass-fiber-reinforced polyesters show promise. The major structural use for plastics, however, remains in the bonding of plywood and other built-up structural materials.

6. Paper

At the time of the survey several companies were planning the production of a house designed to use the surprising strength of

plastic-impregnated sheets of paper, so formed and glued (either as a honeycomb or as a series of corrugated layers) as to form a structural core for stressed skin panels of which the skin might be plywood, aluminum, steel, or possibly paper itself. However, there was no actual production of houses made of this material.[3]

B. By Structural System

Those interested in the production aspects of housing have a major interest in structural systems, but they have shown in the past a common tendency to classify entire structural systems, and particularly prefabricated house systems, according to the design of the cross section of the wall. This practice may be very misleading, since the system employed in the wall is frequently entirely different from that used elsewhere in the house. For that reason, each prefabricated house is here broken down into more or less common component structural parts and the data are classified according to the system used in these component parts. The designations of these classes, furthermore, have been carefully selected to bring out production differences. Thus, while the phrases "frame assembly" and "frame panel" may indicate the same thing in final structural result, the difference between them lies in different amounts of factory prefabrication and different procedures for site assembly. Also, a prefabricator producing a conventional house by fabricating room-size panels is here distinguished from one producing the same house by merely precutting the various pieces. The basic pattern of operations of the prefabricator is indicated as well as the final structural scheme.

1. Frame Assembly

The typical frame assembly is the conventional wood frame house, in the course of construction of which individual framing members are erected at the site and various insulating and finishing materials then applied. The precut lumber house is an example of a fabrication system embodying frame assembly principles.

[3] More information about these designs is given on pp. 233 ff. A fuller description of the material is contained in Chapter 9.

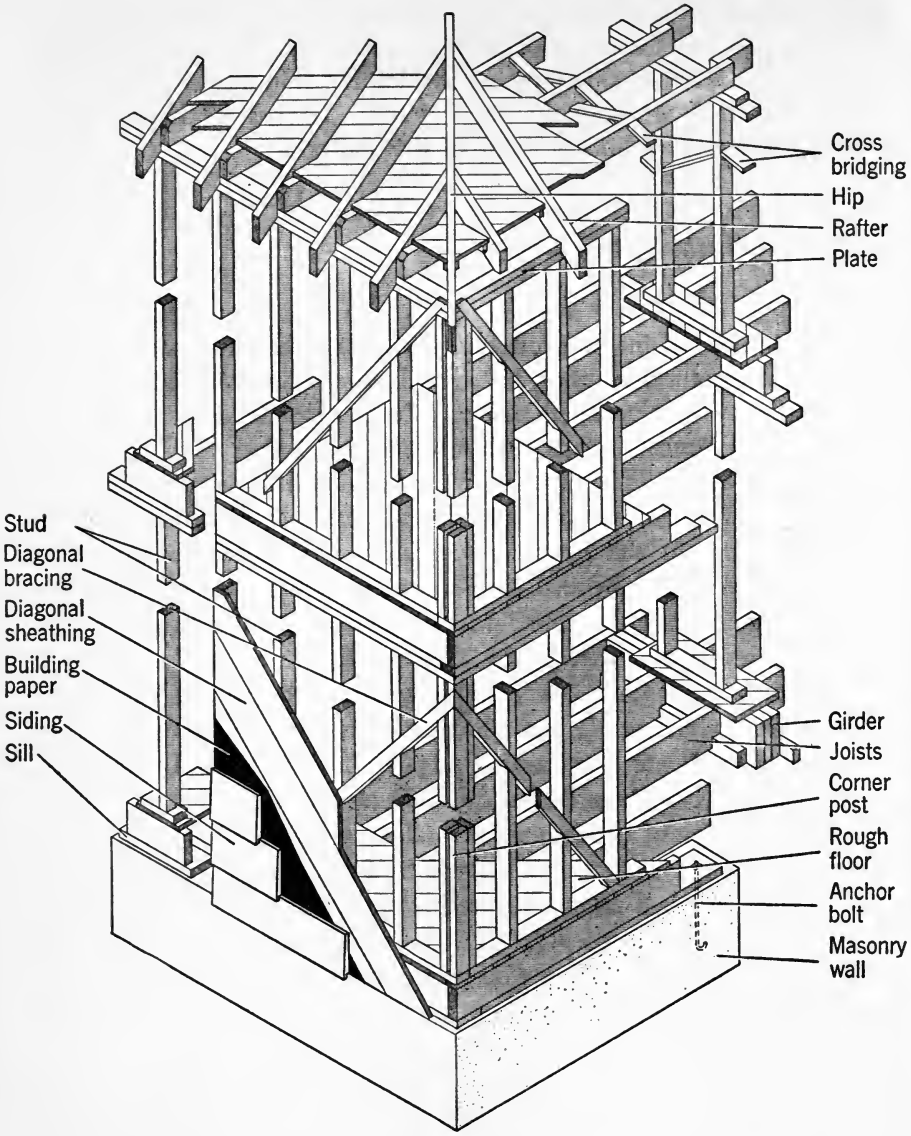


Figure 14. Conventional Framing Illustrating Construction Terminology

2. Frame Panels

In this classification, the structural members are preassembled in the form of panels, and some or all of the insulating and finishing materials are usually applied in the shop in order to save time at the site. The wall panel produced by what may be called the typical prefabricator is a frame panel, made up of framing lumber with wood sheathing nailed to it.

3. Stressed Skin Panels

Where the panels are so designed and assembled that the surfacing elements contribute in a major way to the structural performance of the whole, the result has been classified as a stressed skin panel. Typical design of such a panel is described on p. 228. In some cases a stressed skin action is partially obtained by the use of a single surface material bonded securely to the structural framing and by this means developing some stiffness and strength at the contiguous surfaces. Most constructions having a single factory-applied surface are not securely enough bonded to develop this added strength, however, and so are classified in this report as frame panels, rather than stressed skin panels.

There have been some attempts to approach a monocoque system of construction, but requirements for openings and difficulties with internal shapes discourage the development for housing of a true single prestressed shell. Yet the Harman house made use of the tension stressed steel sheet construction developed by the Lindsay Corporation for truck bodies, and even closer approximations were made in the hemispherical aluminum Fuller house and in Neff's hemispherical and double paraboloid "balloon house."

It is also true that, to a minor degree, nearly all so-called frame systems actually place some reliance upon stressed skin principles, but they are rarely used deliberately to reduce the amount and weight of the materials used. At least in theory, true stressed skin design has a better chance of realization by means of the continuous sheet surface areas, which are well adapted to mass-production industrial processes.

4. Solid Panels

The best example of the solid panel is the precast concrete slab, which is essentially homogeneous throughout. If the amount of reinforcing steel or the emphasis on such steel in the design is considerable, or if laminated panels with plywood or asbestos cement facings are involved, where major structural resistance to load is channeled into skin or reinforcement, the panels should perhaps logically be placed under other structural systems. But where the panel is fabricated as a solid entity (thus excluding honeycomb core materials), and where all parts of the panel assume major structural roles, the designation of solid panels has been used.

5. Poured at Site

This classification includes essentially monolithic structures in which the emphasis in the prefabrication system tends to fall as much upon the pouring and forming machinery as upon the house itself. An interesting monolithic house, poured near the site, was the LeTourneau house, formed in a tremendous and fully mobile permanent form known as the Tournalayer.[4]

This device, and other devices specially designed to make concrete pouring and forming operations at the site efficient and economical, have recently been regarded with a great deal of interest in this country. A factor in this interest has been the recent rapid expansion of the development of lightweight concretes, offering easier handling, better surface qualities, far better thermal properties, and a faster casting cycle than the regular concretes, while retaining sufficient strength to be self-supporting and avoid the necessity of added framing or skins.

C. Miscellaneous Classifications

Before turning to the question of architectural design, attention should be given to two aspects of structural design which are important enough to warrant treatment as separate classifications.

[4] Further detail is given in Chapter 9.

1. Sectional Assembly

The important feature of this classification is not the structural system or the materials used, but rather the degree to which the house is preassembled, by panels or otherwise, into complete volume-enclosing units or sections of the final house. Although the Tennessee Valley Authority was not the first to use the system,[5] this is frequently referred to as the TVA style of construction because of the extent to which sectional and truckable houses were used to provide living quarters for the crews engaged in the various construction projects in the Tennessee Valley. The houses were easy to transport and to put together, and they required a minimum of labor and confusion at the site, thus freeing facilities and roads for the larger jobs at hand. These advantages also frequently recommended sectional house types to those planning special communities for the production of war materials during the recent war, though the TVA houses featured mobility to a degree greater than that required for most residential areas.

Because design decisions were made by the TVA rather than by lending institutions, mortgage insuring institutions, or the ultimate consumers, the result was that the whole construction operation could be planned with assurance from the start, and a greater degree of final finish and building in of furniture was provided than might otherwise be considered a safe risk.

Several different companies produced these houses for the TVA, and houses with similar design principles, such as the Prenco house of the Prefabrication Engineering Co. and the house of Prefabricated Products Co., Inc., were tried out in other parts of the country. The conditions of normal business, however, are different from those faced by the TVA, and the obstacles to be overcome are considerably greater. Nevertheless the TVA experience points up the fact that, under certain conditions, prefabrication in whole house sections can do a clearly superior job.

The sectional house of Reliance Homes, Inc., was an example of a further extension of the TVA principle (see Figure 22). The Reliance house was of steel frame construction, faced with corrugated aluminum over Homasote on the exterior and wallpapered Homasote on the interior. The house was factory assembled into seven three-dimensional room-sized sections, which were completely finished with

[5] General Housing Corporation's sectional house is described in Part I, Chapter 2, pp. 37–8, footnote 55.

wallpaper, wiring, floor covering, kitchen equipment, heating equipment, etc. The sections were transported to the site on three trucks, unloaded by a crane, and assembled into a house in less than a day.[6]

The AIROH house (see Figure 23) in Great Britain, manufactured for the government by Aircraft Industry Research on Housing, is an example of the use of these general techniques in a light aluminum house which has been mass produced in tremendous volume for general residential purposes.

The sectional idea has been carried even further when the complete house has been made available in one piece, as in the case of the well-known house trailer. Several designers have taken this trailer concept and expanded it by ingenious means to produce a true prefabricated house in a single section. Perhaps the best example of this is the Wingfoot Home of the Goodyear Tire & Rubber Co. (see Figure 26). Similar in concept to the earlier Stout Folding House,[7] it was a fully preassembled and prefinished flat-roofed house of stressed skin plywood with utilities completely installed and ready for connection to municipal services. There were two bedroom sections which could be pulled out of the central section in the manner of drawers, expanding the original trailer to a living unit of 253 sq. ft.[8]

These were houses of which it is fair to say that the makers' aim was not so much to supply permanent living quarters for a complete family as to provide temporary houses with far more livability than the normal trailer. Another house under design during the period of the survey, however, carried the same expanding principle even further to produce a good-sized permanent house. This was the house designed by Acorn Houses, Inc. (see Figure 27) to move over the roads in a low trailer bed and unfold at the site into a two-bedroom house of 800 sq. ft. This was made possible by the use of walls, floors, and flat ceiling-roofs of plastic-impregnated paper core with bonded plywood skin, having a cross section thin enough to permit the folding of hinged walls, floors, and roofs against the central utility core during transit. At the site, girders were laid on posts, the floor units unfolded downwards, the walls unfolded outwards, and the roof unfolded over the whole and bolted down. The scheme per-

[6] Reliance designs were considerably changed in the period following the survey. The latest schemes divide the house into three sections, one nesting within the other, so that an entire house can be carried on a single trailer.

[7] Developed in 1937, this was a fully mobile trailer which could be expanded to about three times its original size by folding the side walls up and out to form an additional room on either side.

[8] Construction of ceiling is described on p. 251.

mitted complete factory finishing with a minimum risk of damage in transit or in construction.[9]

2. Modular Design

A great deal of emphasis has been placed upon the principle of the dimensional coordination of building materials and components. This principle must be distinguished from the so-called modular planning long used by many architects in working out plans, although the two have elements in common. Architects' modules have been for the most part space planning tools, used as a means of assuring repetitive structure and planning simplicity at a larger scale, the modules for such purposes running from 3′ or 4′ in the case of houses to 20′ or more in the case of office buildings and factories.

An illustration of the use of architectural planning of this sort may be found in General Panel, which was originally designed to sell not houses at all, but only structural panels in modular sizes (based on a module of 40″) and varying styles, capable of assembly into an infinite variety of houses or other buildings in accordance with the demands of the individual consumer (see Figure 15). It has long been the feeling of Walter Gropius, one of the original developers of the General Panel system, that the best combination of mass-production efficiency and of marketing flexibility could in this way be achieved. At the time of the survey, however, a relatively small percentage of the business of General Panel Corporation of California had been along these lines.[10] A few other prefabricators made additional business for themselves by selling their panels for incorporation by local architects and builders into houses of conventional construction. The HomeOla Corporation sold separate panels several times, and some of the resulting houses were given acclaim in the architectural magazines.

Modular design is of obvious importance in prefabrication. Few prefabricators, however, have understood it as a basic principle of de-

[9] Further details on construction are given on p. 235.

[10] For many reasons, it has been necessary for prefabricators to concentrate on producing a complete house. These modular panels have not been generally available, although recent efforts have been made to bring them into more general use. Even when offering packages of panels to be assembled into specific designs, General Panel has been able to take advantage of this basic flexibility and to offer as many as 25 radically different designs.

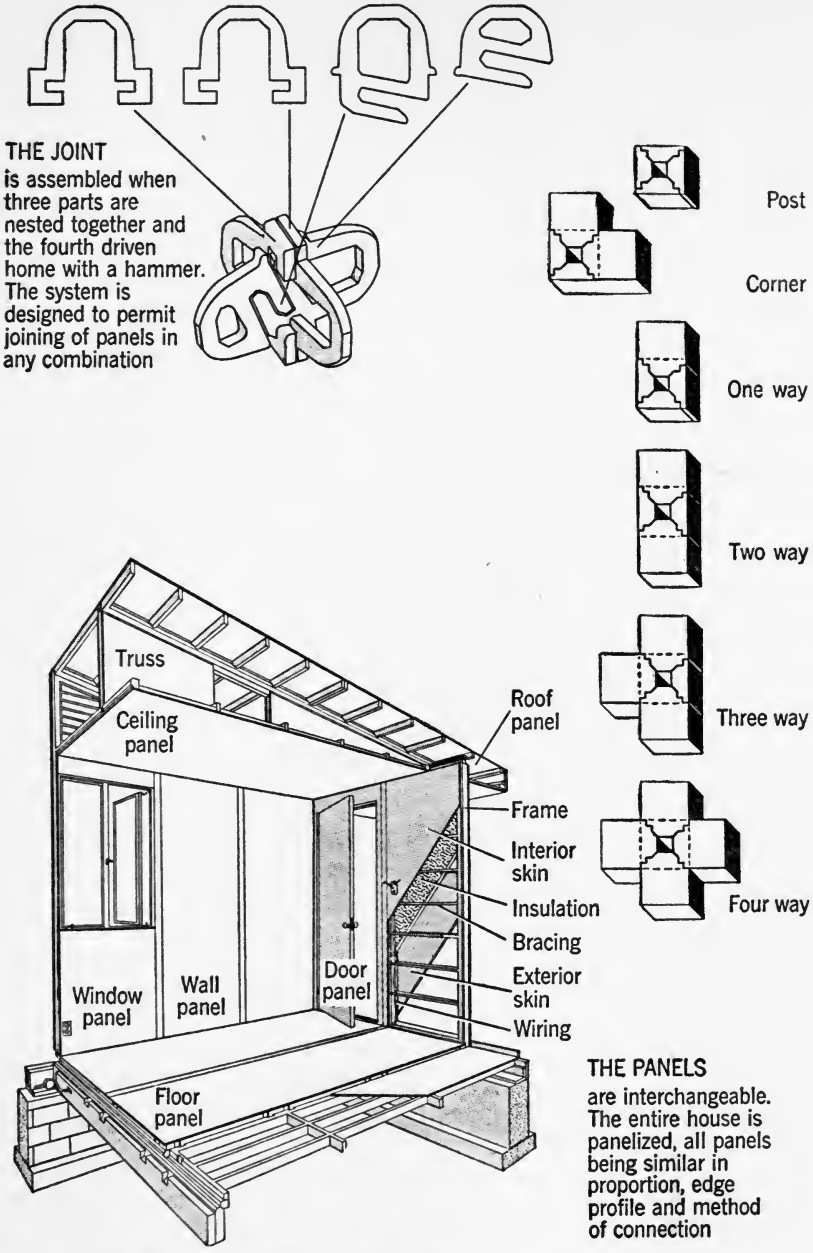


Figure 15. The General Panel System

sign, applicable to all parts of the structure. These basic principles have been briefly sketched [11] as they were developed by Albert Farwell Bemis. All dimensions in Bemis' experimental prefabricated houses (1925–1932) were based on his cubical modular method of design, including dimensions of finish materials and of some equipment. He demonstrated that one result was complete flexibility of layout and theorized that substantial production economies also should obtain.

There are at least two factors which explain why prefabricators do not at present make greater use of modular design. The first is that they have standardized on only one or two or at least a very limited number of house plans. With so little variation of design, complete modularization carries small advantage. In the second place, the building materials industry has only just begun to standardize dimensions on a modular basis, and much of this early coordination has been accomplished by the brick, tile, and masonry unit manufacturers so that it is of little use in prefabrication. Consequently, prefabricators have been forced to choose their materials and equipment from a poorly coordinated industry, and to design their houses around them in the most effective manner to meet immediate needs. Such problems as the interchangeability of wood and metal windows, free choice of built-in mechanical equipment, and complete flexibility of layout have been left to the future.

Although none of the companies in our survey had completely adopted the modular theory of design, a majority of them were benefiting by the use of some planning or manufacturing module. The most common such module was 4″, or some multiple thereof. (American Standards Association official American Standard No. A62.1-1945 states, "The basis for dimensional coordination shall be the standard grid based on the module of 4 inches.")

At least 46 of the companies dimensioned their components in multiples of 2″ or 4″ and, of these, six favored the 40″ manufacturing module, which is not only practicable for local purposes but also is close to the metric module widely favored abroad. Some sort of recognition of the 4″ module was given by at least 62 companies in all.

Other modules were used, however. At least three companies used a basic module of 3″; two used 39″ as a manufacturing module; and one used 4′ 3⅝″ as a manufacturing module.

[11] Part I, Chapter 2. Extensive design details are available in the *A62 Guide for Modular Coordination* (Boston: Modular Service Association, 1946).

Of those not using modules as a design or manufacturing basis, most were producing but one or a very few standardized models which permitted a relatively standardized production. Some claimed that, by disregarding modular dimensions, they were able in practice to effect saving in the fitting of equipment and the sizing of rooms. On the other hand, others making a limited number of models still found advantages in modular dimensioning. Thus Harnischfeger made up panels in widths of any multiple of 4′, and found that it gave his dealers a good deal of elasticity in the erection procedures selected. Some preferred to handle 4′ panels as such; others asked to have them preassembled in 12′ and 16′ lengths; and at least one asked for delivery in the form of fully assembled wall-length panels, to be erected at the site with a crane.

3. Architectural Style

One of the oldest and certainly one of the most popular methods of classifying houses is by the general appearance or architectural style. Aside from simply describing the basic surface material, this is indeed probably the way most people try to describe houses to one another. Those trained in architecture, however, would be the first to say that this is something less than the ideal method, because general appearance and architectural style may mean very different things to different people.

As has been said at the beginning of this chapter, this entire book is concerned with architecture in the broad sense. The materials and structural design, the production system, and the erection scheme are far more important to the architecture of prefabrication than the so-called style in which the final house is clothed. Yet classification by architectural style cannot be entirely dismissed here, because it is a matter of great concern to most prefabricators, however widely their interpretations of architectural treatment may vary.

A few prefabricators, including some of the prominent names in the business, have little use for architects and profess to believe they have nothing to offer the prefabricator. At the other extreme, several prefabricators have come into the field directly from architecture. Some of these are crusaders, and a few appear to be far more interested in expanding the vision of the public and of their profession than in making houses on a business basis.

For most of the prefabricators, however, good architecture is but one of several important aspects of the business, and they take steps to get it, according to their understanding of the term. As might be expected, the most rational architectural approach has generally been found in the companies making the greatest innovations, for in such cases the importance of the architect in producing a livable and salable house by the new techniques becomes obvious. Probably architecture has had the least influence on those companies devoted to manufacturing, by a somewhat more industrialized process, the same kind of conventional house as is built in the area by speculative builders. Yet even these often found a business advantage in devoting time and money to the appearance of the house and to the gadgets and decorations which frequently pass for architecture. The advertising world has created too vivid a picture of the normal American dream house to be disregarded.

In factual terms, by far the majority of the prefabricators during the period of survey were satisfied to put before the public what can only be called conventional houses, either as the result of careful deliberation or only unconsciously, because that was what a house had always meant to them. At least 80 companies came in that group. On the other hand, perhaps 40 wanted something different, usually along the lines of what has been called "modern" architecture. Architects would probably classify as of sound design—whether conventional or modern in spirit—about one-quarter of these prefabricated houses, or very little more than would be the case with conventional houses. In about the same fraction of houses, often although not always the same, were the services of an architect employed somewhere along the line.

The value of architecture to most companies lay in its relation to marketing, and it was for the most part thought of primarily as a sales feature. Some prefabricators, in fact, spoke of a "basic house" to which such "architectural treatment" as false gables, long shutters, and special entrance details were to be added, often as extras. They were usually convinced that houses of modest and conservative appearance, reminiscent of the Cape Cod cottage, represented the safest gamble, and in this opinion they were reinforced by the commercial failure of several attempts to market more advanced designs. Many were, however, becoming convinced that in recent years the architectural tastes of the public have in some respects been tending to move away from the Cape Cod cottage. The suggestions of open planning contained in such terms as "picture window" and "ranch-house style" were becoming stronger, the more so the farther west in

the country, and the wide appeal of the all-on-one-floor house was recognized. Few, if any, of the larger companies produced a two-story house. A sizable group produced, and perhaps twice as many were contemplating, a story-and-a-half house, usually of conventional design with two bedrooms planned for the second floor but not finished, but in most cases this was done primarily for reasons of economy.

The largest single factor in making the prefabricators conscious of a more fundamental sort of architecture in terms of sound space planning and construction probably was the requirement, often a matter of life or death, that their houses meet the approval of the FHA. A certain minimum good design was assured in this way, but it is clear that the narrow views of many financiers on architectural matters were a severe limitation on those whose training was good and who were eager to offer an architecturally sound house created by a new approach.

The Reliance house, first designed by William Lescaze with a flat roof, was refused approval for mortgage insurance by the Philadelphia FHA office, though the design met with no objections from the national FHA office. The Philadelphia office, stating that the design lacked "to a substantial degree those essential esthetic qualities and visual appeal which are necessary to assure continued marketability," [12] required that a pitched roof be added to qualify the house for mortgage insurance. The local office later did permit the flat-roofed houses to be erected, after finding that their acceptability exceeded that of the pitched-roof variety.

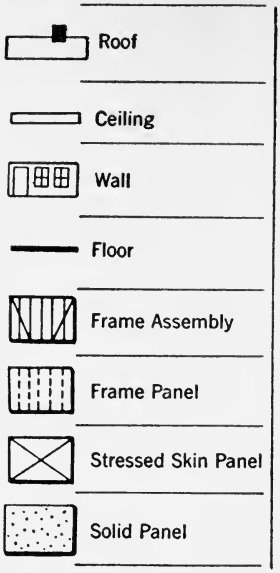
III. Description of Components

A. General

In the discussion which follows, the system of classification by structural system is applied in detail, not to the house, but to its major components, using for this purpose those components into which the

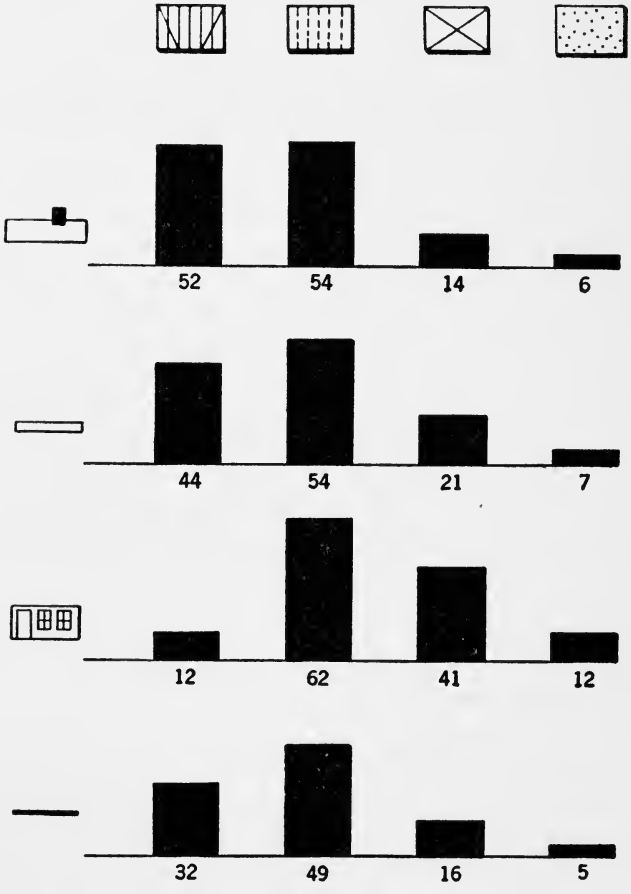
[12] *The Architectural Forum,* 88 (March 1948), 11.

Chart **A**



Construction Used in Prefabricated Components

Notes: Design information was analyzed for 125 companies in all. In some cases the information required to prepare these charts was not available. In other cases, companies could properly be listed in more than one category. The totals should not, therefore, be expected to check with the headings in every case. At least 25 companies used concrete slab floors for most of their houses. Many more used slab floors occasionally.



house is most readily divided, namely: foundations, floors, walls, ceilings, and roofs. Chart A gives a breakdown of companies according to the structural system used in their various component parts.

For each component, there is a breakdown according to structural system (as defined in the last section), and within each such subdivision, as fully detailed information is given as possible. Thus, in order to find the wall-panel size most commonly used by prefabricators of houses of stressed skin plywood construction, it is necessary to turn to the component "walls," and under it to the structural classification "stressed skin." (In this case, there was no single preference; prefabricators were almost evenly divided between 48″ panels and room-size panels.) So far as possible, this information has been made available in tabular form, and from a brief scanning of these tables the characteristic construction systems become apparent.

It should be recalled that the survey did not include the entire industry, that there was a predominance in numbers of small-shop fabricators of essentially conventional houses, and that the producers of potentially great numbers of new types of houses were in few cases in production and in no case in full production. The numbers which appear in these tables, therefore, are not suitable for statistical analysis; they serve rather to give a generally accurate picture of the industry.

One general comment which is made here in order to give it due importance concerns the treatment of detail. In most of the houses studied, particularly the interiors, there was an element of crudity—lack of refinement of details, lack of precision of manufacture, and insufficient attention to materials used for interior finish—which could well do injury to the whole product. By and large, this was no more true of prefabricated houses than of conventional houses built during the same period, but the prefabricators could far less afford to have criticism focus on such matters.

B. Foundations

Very few house manufacturers supply any sort of prefabricated foundation, and there are almost as few specialized manufacturers of prefabricated foundations. Several prefabricators did supply concrete posts or wooden piers, however, and two companies even had precast slabs for use in forming basement walls and floors, but except for specialized local operations prefabricators saw no economies inherent

in the use of precast concrete slabs for basements because of their weight and bulk and general difficulty of handling, and because simple means of construction at the site were readily available. Nevertheless, special handling devices make it possible to move precast slabs into place, and several companies were working at least experimentally on the simplification of their foundation construction work.

Of the companies studied in the survey, at least 16 designed their houses specifically for a basement and supplied detailed foundation plans, although in most cases the basement was to be built by the local builder. These prefabricators were predominantly in the north, where continuous foundation footings to a depth as great as 4′ might be called for anyway, but they also felt that the public wants basements, as shown by almost all conventional houses in some areas. The arguments for the basement stress the large amount of storage and general utility space thus made available at a relatively low cost, and these considerations have enough weight to persuade at least 47 of the other prefabricators, who do not insist upon basements, to offer them as an optional feature.

Those opposed to the use of basements point out that they add cost to the final house—on the average about $500—and that the functions usually allocated to them can more safely and efficiently be performed above ground in space designed for the purpose. Essentially, these men say, the basement is incompatible with the concept of prefabrication which would reduce site work to a minimum, and which requires the timing of site preparation to be as simple and dependable as possible. To schedule steady sales throughout the year, a northern dealer would have to tie up money in many basements made ready in good weather to handle house erections in bad.

This argument depends upon many design factors, and cannot be settled once and for all,[13] but the advantages to the prefabricator of the basementless house are such that there has been a strong tendency to build such houses, even in northern climates. At least 56 prefabricators produced basementless houses exclusively. A few of those experimenting in northern and eastern areas with such houses found better public acceptance than they had expected, particularly if construction economies were passed along to the consumer. On the other hand, several companies selling large quantities in northern climates when they gave the option of basement or no basement found that the market preferred the basement. Of course, this may be

[13] An interesting study has been made by the HHFA on "Basements vs. No Basements for Houses," *HHFA Technical Bulletin*, no. 8 (January 1949), pp. 47–59.

attributable to the nature of the differences in the design and cost of the two types as much as to a preference for the basement as such.

The majority of basementless houses were placed on continuous foundation walls of some sort—either poured concrete walls supporting a wooden or concrete floor system, or the edge of a floating slab designed in effect as a grade beam. Only a few of the houses, 15 in all, and mostly the smallest and least substantial, were placed on piers or posts. This was in part the result of FHA, building-code, and banking requirements of continuous foundation walls.[14]

Little new development has taken place in foundations, and that has been done mostly in connection with basementless houses. Some of the ideas developed for houses on pier or post foundations include the use of special built-in jacks to level the house on the permanent foundation system (TVA), the use of precast concrete discs with holes in the middle strung on an iron pipe to build up masonry posts (Swedish), and the use of precast concrete posts which are hung from the jacked-up floor beams (see Figure 16) until the bulk concrete footings poured about the posts have had time to harden sufficiently to permit the removal of jacks (Acorn).[15]

With the grade beam foundation, which is not necessarily footed below the frost line, there has been quite a bit of experimentation, and study is in progress. In at least one case it was proposed to use radiant heat in such a slab to prevent frost formation in the ground beneath it. Most designs, however, set out to defeat frost heave by using sand and gravel under the slab and by otherwise naturally or artificially keeping the underlying soil well drained. Some designers claim that the loading of many domestic superstructures is so light that little damage is likely, to structure, foundation, or plumbing, as the result of the temporary lifting of a corner through mild frost heave.

Perhaps the second largest problem of the grade beam or slab foundation is that of insulating the walls and the corners and edges of the floor from the cold. This problem has been the subject of a great deal of study and is more fully discussed on p. 208.

[14] These requirements are becoming more liberal, and a pier or post foundation, with proper insulation in the floor, is now acceptable in many more localities than at the time of the survey.

[15] Recent work by HHFA engineers tends to show that adequate ventilation of the crawl space under such houses is the only surely effective means of preventing accumulation of moisture in the wood of the structure above (*HHFA Technical Bulletin*, no. 8 [January 1949], p. 107).

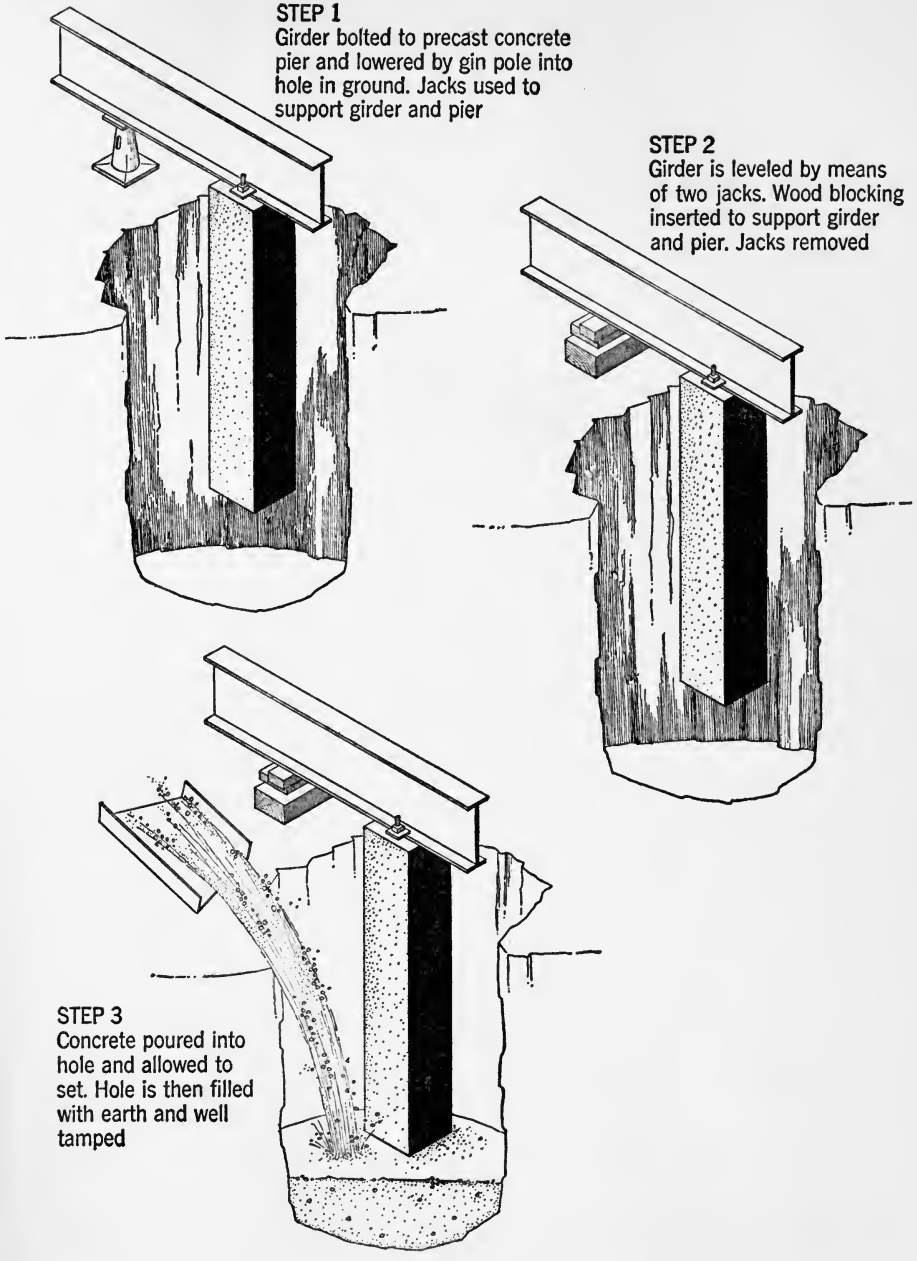

STEP 1
Girder bolted to precast concrete pier and lowered by gin pole into hole in ground. Jacks used to support girder and pier
STEP 2
Girder is leveled by means of two jacks. Wood blocking inserted to support girder and pier. Jacks removed
STEP 3
Concrete poured into hole and allowed to set. Hole is then filled with earth and well tamped

Figure 16. The Acorn Footing

1. Frame Assembly

Under this heading are included floor structures which are made up at the site from precut or otherwise prepared members. A large

Chart **B**

Frame Assembly Floor

32 Companies

Frame members	29	wood
	3	steel
	21	2″ × 8″
	8	2″ × 6″
	26	16″ o.c.
	29	nailed
	2	bolted
Structural floor	15	plywood
	16	wood
	9	5/8″
	9	1″
	30	nailed
	1	bolted
Finish floor	7	prefinished hardwood
	4	unfinished hardwood
	25	nailed
	3	glued
	1	glued and nailed

number of manufacturers who panelized walls and other portions of their houses preferred to precut the floor system, probably because of the bulkiness of panels built up with joist-size lumber, the difficulty of achieving a solid and silent structure, the known mar-

ket preference for a continuous hardwood floor, and the relative advantages of site assembly over prefabrication in making allowance for imperfectly dimensioned foundations and in permitting the use of diagonal lumber subflooring. In all, 29 companies used frame assemblies of wood in their floors.

It is significant, however, that three of the largest companies (National Homes, HomeOla, and Houston Ready-Cut) made use of wide-spaced (4′ o.c.) steel framing members (I beams, channels, or open web bar joists) on which framed wood sections were placed, and at least as many more were considering use of this system.

A summary of the data on frame assembly floors is presented herewith (Chart B). This chart and the others which follow it give only a selection of the most useful information from our survey.

Although no such system was actually seen in use in a prefabricated house, the National Lumber Manufacturers Association has publicized the design of a floor of 2″ × 6″ dressed and matched tongue and groove planks laid over girders 6′ 0″ o.c. According to the preliminary figures of the Association, this offered hope of savings as high as 26% on labor and 14% on material in comparison with the conventional system, and might add as much as 24% to the insulation value. It had been used by architects and was being seriously considered by several of the prefabricators.

2. Frame Panels

Chart C presents a summary of the details of construction used by the 49 companies which employed frame panels in their floors. The variation in sizes and spacings of floor joists in these panels is the result not so much of building regulations or differences in engineering standards as of variation in structural floor (usually subfloor) thickness and design.

Floor panels used in basementless houses are usually insulated, particularly in northern climates, and the importance of vapor barriers is beginning to be realized. For the installation of insulation and vapor barriers, factory assembly appeared to offer some advantages over field installation, although only 14 companies gave definite indication of providing both, and among them there was wide variation, both in materials used and in method of installation. Some took the chance that insulation, even thin reflective insulation, might be damaged in transportation and handling, and made no effort to

Chart **C**

Frame Panel Floor

49 Companies

Frame members	46	wood
	3	steel
	26	2″ × 8″
	17	2″ × 6″
	2	2″ × 3″
	44	16″ o.c.
	2	24″ o.c.
	39	nailed
	5	glued and nailed
Panel size	17	4′ × 12′
	6	8′ × 12′
	3	6′ × 12′
Joint*	33	butt
	5	interlock
	3	spline
Structural floor	23	wood
	21	plywood
	2	steel
	1	metal lath and concrete
	16	1″
	11	⅝″
	3	¼″
	39	nailed
	7	glued and nailed
Finish floor	16	prefinished hardwood
	16	unfinished hardwood
	39	nailed
	3	glued
	1	poured

* Types discussed pp. 218 ff.

protect it or box it in, probably on the theory that where boxing can be avoided and bridging done at the site there are certain advantages of nesting panels during shipment.

The difficulties of factory application of finish flooring are emphasized by the relatively small number of companies which attempt it. Unless joints [16] between panels, always a problem in floors, can be concealed under partitions and thresholds, it becomes a handicraft operation to make them tight, and there are additional problems of protecting the assembled and sanded floor in handling. Since floor panels also tend to be large, the factory application of finish flooring tends to make them hard to manhandle, particularly if lumber subflooring is used. With rougher floor panels, simple butt or lap joints can be used, and the finish floor applied in the field.

In order to avoid doubling of framing members at the joint, several companies have changed from butt joints to some variation of lap joints, which require a higher degree of subfloor uniformity and thus place some advantage on the use of plywood for the structural floor instead of lumber.

3. Stressed Skin Panels

Chart D presents a summary of the construction details of the 16 companies using stressed skin panels in their floors. From the point of view of reducing weight, stressed skin panels have definite advantages, and the double skin makes a substantial increase in the thermal-insulation value of the floor. It further obviates any necessity for bridging between joists. However, some care is required to prevent condensation within the panels.

It will be noted that these panels are not produced in noticeably larger sizes than the frame panels, despite the possibilities offered by lighter weight, and that the joints in such panels tend to become more complex because of the inability to get at the interior of the panels, although in some cases hand holes were provided as access for bolting or other inside connection. These joints, in addition to providing continuous structural connection, were used to position the panels, and a feature was often made of their special characteristic of making the whole structure demountable. In some cases, however, they become so complex as to require rather expensive millwork pieces.

[16] Joint types are discussed on pp. 218 ff.

Chart **D**

Stressed Skin Panel Floor

16 Companies

Frame members	15	wood
	1	steel
	1	aluminum
	7	2″ × 6″
	2	1″ × 6″
	2	2″ × 8″
	2	2″ × 4″
	12	16″ o.c.
	11	glued and nailed
	2	nailed
	1	glued
	1	bolted
Panel size	4	4′ × 8′
	2	4′ × 12′
	2	4′ × house width
Joint	5	butt
	4	spline
	4	interlock
	2	lap
Structural floor	16	plywood
	7	½″
	5	⅝″
	2	⅜″
	11	glued and nailed
	2	glued
	2	electronic glue
	2	riveted or bolted

Finish floor	5	plywood (3 rotary, 2 edge grain)
	4	unfinished hardwood
	3	optional
	3	asphalt tile
	5	glued
	4	nailed
	3	glued and nailed
	1	stapled

At the time of the study new interest was being displayed in the use of edge-grain plywood as a finish floor and subfloor combined, to be applied in one sheet. This was used by only two companies, and it was not known at the time whether a cost saving could be made in this way or not. However, it was generally felt that rotary-cut fir plywood would not be satisfactory as finish flooring, because of its relatively poor and uneven wearing quality. One company used oak veneer as a factory-finished floor surface, but it appeared to be rather expensive at the time. There was little experimentation with the new composition floor materials.

Nearly all companies used linoleum flooring in the bathroom or kitchen or both, but none attempted to apply this in the factory. It was interesting to note an increasing tendency to use asphalt tile flooring throughout the house, in the case of wood floor systems as well as that of concrete, and, when used, it seemed to meet with little marketing resistance.

4. Solid Panels

Only five companies used solid panels in their floors, and these were for the most part precast concrete panels. The fact that so few companies used such floors may be explained in part by the fact that only one smooth surface is required for a floor, and companies using precast wall slabs find it simpler to cast the floor slab on the ground at the site.[17]

Where there is a basement there is the possibility, not actually tried by any of the companies in the survey, of constructing a floor

[17] Nevertheless, there are indications that certain techniques, such as the Vacuum Concrete process and the use of prestressed reinforcing, together with some means of bedding them down firmly, may make it economically possible to use precast concrete floor slabs, particularly in large projects.

with long precast and prestressed reinforced concrete beams which have a rectangular cross section and usually a hollow central core. Such beams were widely marketed by The Flexicore Co., Inc., and at least two other companies for use in conventional construction, and they offered interesting possibilities for specialized construction if joint problems could be handled.

5. Poured at Site

At least 25 companies were using poured-at-site floor construction, the great majority of them using asphalt tile or linoleum for their finished floor surface.

Since concrete is a porous material and a poor thermal insulator, it was becoming increasingly obvious to these companies that careful attention must be paid to insulating it from both the ground and the outside air (see Figure 17). Western firms, with longer experience in this sort of construction, were often found to exercise great care in the placement of a waterproof membrane beneath and around the edges of the slab—usually hot tar and #15 roofing felt—even where no insulation was required.[18] Many of the slabs produced for northern climates, however, seemed deficient in insulation.[19] The possible use of lightweight aggregates having better insulative qualities and of waterproofing admixtures was under consideration at the time of the survey.

The development of the ground slab was being spurred not only by materials savings, labor simplicity, time savings, and generally lower costs, but also in some degree by the regulations of the FHA

[18] The Byrne Organization takes the following precautions with slabs cast directly on the ground:

"All slabs have a porous sub-base of considerable thickness with a perimeter grade beam around the building sufficiently deep to be below the frost line and to cut off subsurface water. . . . We never locate slabs on lots which have an accumulation of water through poor drainage. The top of the slab is furthermore placed about a foot above the ground which is carefully graded away from the building on all four sides." (Letter from Wesley H. Blank, Chief Engineer of the Byrne Organization, to the Bemis Foundation, July 31, 1947.)

[19] See "Insulation of Concrete Floors in Dwellings," *HHFA Technical Bulletin,* no. 8 (January 1949), p. 149. Also *Concrete Floors for Basementless Houses,* Small Homes Council, University of Illinois, Circular Series F4.3 (August 10, 1948).

requiring a large ventilation space under a platform floor and above the ground in the case of a basementless house. Many companies felt that their small houses would have an awkward appearance and

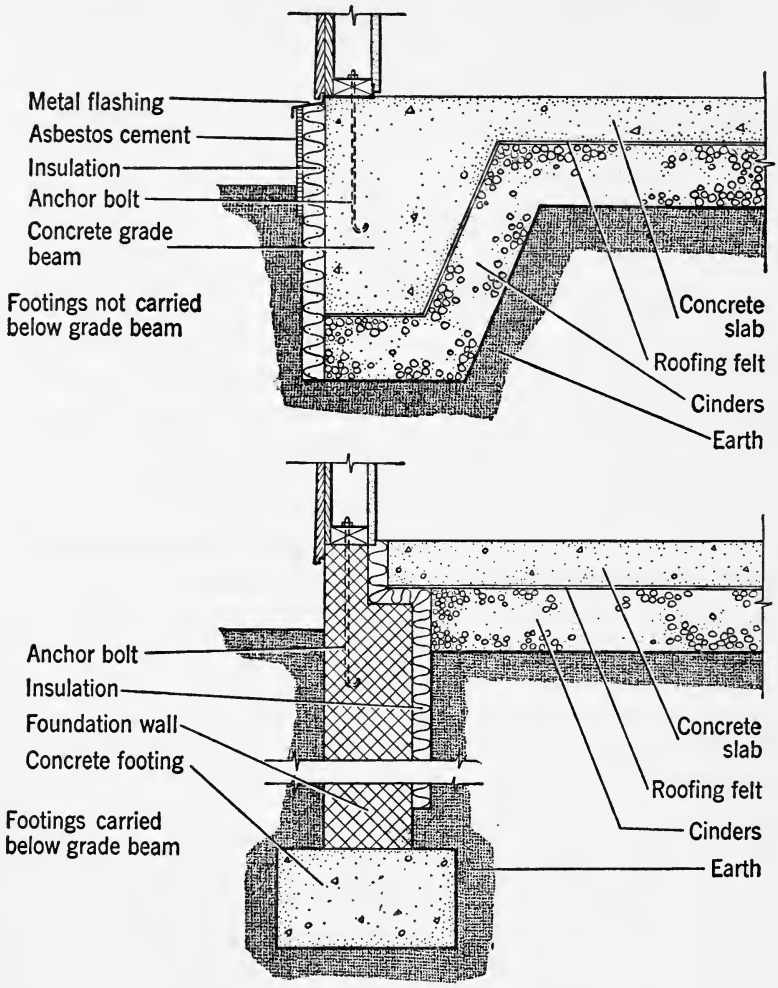


Figure 17. Examples of Grade Beam and Concrete Slab on Grade

serious marketing difficulties if built up too high above the ground level, and there was reason to believe that the public was not seriously opposed either to the basementless house or to the ground slab floor.

1. General

Prefabricators, housing theorists, and rationalizers of construction in general have devoted more attention to the construction of walls than to that of any other part of the house. The human being, viewing the world primarily in a horizontal plane, seems to assume that walls make the house, and the inventive mind has long dwelled on the possibilities of creating an ideal material to serve all the functions of the wall cheaply and efficiently.[20]

Nearly every prefabricator manufactured some major part of the house walls, and many manufactured nothing but the walls and were looking forward to the day when they could get into the extensive non-residential field as well. Yet to manufacture the walls, or walls and roof, leaving the bulk of the house to be provided locally, is to realize only a part of the potential advantages of prefabrication; indeed, because of the number and variety of openings required, some prefabricators claim that it is more difficult to manufacture walls than floors, ceilings, or roofs. To most of the companies in our survey, however, considerations of rationalization for large-volume production, or of marketing only stock components for assembly as desired by the local purchaser, were not important. These companies were out to make a profit by simplifying somewhat, improving somewhat, or lowering costs somewhat, without substantially altering the normal house as it is known and as it has become acceptable to the public. The system developed for the production of walls was, in most cases, at the heart of the whole scheme.

2. Frame Assembly

Precut houses. There was a steady production of what was known to the trade as a "precut" house, in which not only the walls but the whole structural frame and much of the finishing material were precut and shipped in a single house package. Such a package rarely

[20] Walls and partitions represent from 30% to 40% of the total construction cost of a house if millwork and interior and exterior finishing are included.

contained more than the necessary wooden pieces and possibly some roofing or flooring materials in addition. Although this system may offer a few specialized advantages (for example, minimum bulk for export purposes), it is basically a conventional frame structure with marketing advantages depending on price and convenience rather than design. In fact, in most cases, the precut houses were clearly not better designed from the architectural viewpoint than the average conventional house.

At the time of the survey the National Retail Lumber Dealers Association had offered the "industry-engineered house," based on modular coordination in wood frame design, efficient precutting, and a rational assembly system.[21] The Peerless Housing Company, Inc., was also at work on precut houses of advanced design, making use of special assemblies such as trusses and girts and millwork of standardized parts to obviate the need of more complicated assembly, and further simplifying erection operations by procedures designed to eliminate the chance of confusing the various precut pieces—a chance which, together with the tendency of the local erection crew readily to give up the search for required pieces and cut other pieces to fit, has long been a special difficulty of the precut house.

Frame and curtain wall construction. This usually involved wide-spaced framing members which wholly support the roof system, leaving no structural function for the "curtain walls" applied to these members. In some cases these systems can be termed "exoskeleton" systems since their framing members are exposed on at least one side of the wall. As such they have an unconventional and not unattractive appearance.

Such a system was used in the house designed by the John B. Pierce Foundation and produced primarily as the Celotex Cemesto House (see Figure 24). This house had $4'' \times 4''$ posts as much as 12′ o.c., with the edges of the Cemesto[22] board curtain panels enclosed within the posts themselves, and with the roof load carried to the posts by built-up plywood girders placed horizontally at the top of the posts. Above the 4′ high tier of Cemesto panels placed above the floor and its capping lumber member came a second tier which, because it served no structural function, provided a great deal of freedom for the location of windows and other openings. The system was used extensively during the recent war (together

[21] The "industry-engineered house" plan was used by the University of Illinois Small Homes Council for its time study of construction methods, *Research Report on Construction Methods.*

[22] A sandwich board made up of fiberboard filler with asbestos cement facings.

with a vertical type using posts spaced 4′ o.c. and eliminating the special top girder), and the free fenestration and low cost appear to have overbalanced the special requirements of the system: high precision millwork in dimensioning the framing members, and careful protection of the edges of the Cemesto panel against fracture in handling and against moisture in use. Many such houses have been erected since the war by private builders.

One such builder, Modern Standardized Buildings Co., made use of the 4′ spaced post and Cemesto panel system in a variation specially designed to avoid the costs of select grade lumber, millwork construction, and other expensive finishing detail, and to take advantage of the properties of protective mastics and paints. The design was expected to yield cost savings even with small production volume because of simplified production and erection procedures.

Another frame and curtain wall system of interest was the so-called "Ratio Structures" house of Wiener, Sert, and Schulz, developed during the recent war.[23] Exterior wooden posts 13′ 4″ o.c. supported longitudinal beams and tie beams which in turn supported a series of curved plywood-covered panels to form a continuous arched roof. A secondary framing system in the walls, using a spacing module of 3′ 4″, was filled with solid insulated wall panels, windows, or doors, as the case might be. Interior partitions in the temporary war projects which used this system were built up of laminated fiberboard on wood frames and jointed by the use of plywood splines, and fiberboard ceilings were hung from the tier beams. This system, like the Pierce system, offered great elasticity in the design of openings, but the secondary framing system tended to be a needless and somewhat wasteful duplication of the primary roof support system.

Production Line Structures offered a good example of another frame and curtain wall system of special interest (see Figure 25). In this system, half frames composed of wooden members and nailed plywood gussets were brought together at the site to form, in effect, three-hinged arches 4′ o.c.; these were tied together at the ridge and eaves by longitudinal members and at the lower ends by plywood panel members. Continuous openings between structural members above these panels were filled in at the site by wood awning-type windows or by solid panels, as the location might dictate. End walls were light framed and plywood covered, and they served structurally only as stiffeners. The house was designed for

[23] *Modern Designs for Prefabricated and Demountable Buildings,* Office of Production Research and Development (Washington, 1944).

ready production, in a standard width but in any multiple of 4′ in length, by the use of standard parts. This design was suitable primarily to warm climates; its contemporary quality may be shown by the fact that it received first citation in the 1946 *Progressive Architecture* Awards.

Metal walls. In this group were metal systems ranging from those which largely imitate wood frame structure to those in which some element of stressed skin design is employed in order to take advantage of the possibilities offered by metal for production of thin, strong, and standard sheets. In metal structures the line cannot easily be drawn between frame assembly, frame panels, and stressed skin panels. Classification of a system often depended upon whether, at the time of the survey, the framing members went to the site as separate elements or preassembled into panels, or whether at that time the manufacturer was shipping out his parts "knocked down" or had the time and factory space to do a certain amount of preassembly. In general, if panels of some sort were preassembled, the system was classed as frame panel, and if great reliance was placed on stressed skin design, the system was considered under that heading.

Typical of the steel systems in which metal studs serve simply to replace wooden studs was that put on the market by Stran-Steel, in which the stud was specially designed to permit nailing into it. Nevertheless, the Stran-Steel Arch Rib Homes—an outgrowth of the wartime "Quonset" huts—were very different from wood design. They produced a structure of semicircular arch section, enclosing the house volume with substantially less material and avoiding the difficulties usually encountered at the juncture between roof and wall. In this system, corrugated sheet-metal cladding was applied to the exterior side of steel ribs spaced 2′ o.c., with paint, special protective coating, or insulation used according to the circumstances. In many cases, roof sheets were raised from the main framing to permit continuous ventilation under the roof. Windows, doors, and other openings along the sides of the structure ordinarily were vertically framed bay extensions of the structure, often in wood. The final product was used in many different situations, frequently producing very interesting variants on the usual themes of domestic architecture.

In systems of this sort special care has to be taken to avoid condensation resulting from contact between the highly conductive metal skin and the frame. The use of horizontal rather than vertical corrugation helps to reduce the area of continuous contact between

these two, and the furring out of interior wall surfaces on wood battens, the separation of skin from frame by insulating felt or rubber strip, and the provision of weep holes and drip on the inside of the wall to permit escape of moisture which accumulates on the underside of the skin, are examples of other design devices employed to improve the residential qualities of this sort of construction.

A frame assembly house construction system of aluminum was offered by the Fox Metal Products Corporation. In this system, the basic framing member was made up of two 6″ channels of 0.064″ thickness bolted back to back to form an I section into which facings and insulation could be screwed or nailed; the I sections were spaced 2′ o.c. Exterior surfacing was 0.040″ thickness aluminum sheet, crimped for stiffness in such a way as to resemble clapboards. The crimping reduced the area of contact between exterior surface and frame, and further protection was offered by an insulating strip of asphalted felt. The interior surface was generally ⅜″ Upson [24] board, applied over a 1″ blanket of compressible insulation where required by climate, and held in place by cold-rolled vertical aluminum batten strips. Partitions were formed of 4″ I-section channels having Upson board on both surfaces. The roof structure was much the same as the wall, with additional insulation and with a layer of Upson board placed immediately beneath the exterior surface as well. No further finishing was required for wall or roof surfaces. Windows were wood framed casements, placed in the 2′ space between studs.[25]

Another frame assembly house, basically of steel, was that of the Harman Corporation. This house was one of the earliest to receive a guaranteed market contract (for 4,200 houses), and it was later widely publicized by the failure of the company. This house used the Lindsay trailer body structural system in applying thin sheet steel (26 gauge on walls, 24 gauge on roof, galvanized) in tension as an exterior surface over steel wall studs and roof trusses 39″ o.c. When completed at the site, therefore, this became a stressed skin system, with the skin bracing the entire structure. An interior lining of insulation and wallboard was furred out from the steel members with wooden strips, and insulated partitions were made of light steel

[24] Upson board is a laminated fiberboard available in room-sized panels.

[25] More recently, Fox Metal Products Corporation has supplanted this model with its Marquette home, which varies from this description in many respects, particularly in the use of plywood interior finish, of more extensive insulation, and of a peaked roof finished with sheathing lumber, asphalt-saturated felt, and asphalt shingles.

framing members with wallboard applied to both sides. Windows were of the steel casement type. The exterior was finished with a special paint, designed to derive added weather protection from imbedded grains of stone and similar to stucco in appearance. Harman did a substantial amount of engineering in adopting various existing and new materials to the final house, but the company operated primarily as an assembly plant, purchasing most of its components elsewhere, and it was notable for the completeness of the package furnished from the plant. The system inherently required a good deal of relatively skilled site labor and led to unusually high erection costs.

A metal frame assembly house even better known not so long ago was the hemispherical Fuller house (see Figure 28). The entire weight of this structure was borne by a central mast composed of seven high-strength alloy steel tubes bound together. The mast rested in a concrete footing, and three steel rings were hung from the top of the mast, one below the other in widening circles. These rings changed the direction and fixed the position of the tension wires which supported the structure. The tension wires were fastened to the top of the mast and supported the outer edge of the circular floor structure, which was composed of wedge-shaped pressed aluminum floor beams with their narrow ends supported by the central mast. Curved ribs, acting in principle like those of an umbrella, supported the roof skin of aluminum. The side walls were curved double aluminum sheets with space between for insulation. Since the interior was entirely free of structural members with the exception of the central mast, the room arrangement was quite flexible. The final house was a metal stressed skin structure, but it was contemplated that it would be shipped knocked down, with its various framing members and skins packaged into a cylindrical container 4½′ in diameter and 16′ long, so it is therefore classified here as a metal frame assembly.

Chart E presents a general summary of the construction details of the twelve companies using frame assembly in their walls. The great variety of systems falling under this heading is immediately apparent.

Chart **E**

Frame Assembly Wall

12 Companies

Frame members	9	wood
	4	steel
	5	2″ × 4″
	4	16″ o.c.
	4	24″ o.c.
	1	4′ o.c.
	7	nailed
	4	bolted
	1	glued and nailed
Insulation	2	metal foil
	2	gypsum board
Vapor barrier	2	metal foil
	1	paper
	1	asphalt membrane
Exterior structural cladding	4	wood
	2	fiberboard
	2	plywood
	7	nailed
	3	screwed or bolted
	1	glued and nailed
	1	troweled
Exterior finish	2	wood siding
	2	wood cladding
	2	metal cladding
	2	fiberboard
	3	nailed
	3	special
	2	screwed or bolted
	1	troweled

Interior surface	5	gypsum board
	4	lath and plaster
	2	plywood
	4	nailed
	4	troweled
	3	screwed or bolted
	1	glued and nailed

3. Frame Panels

The most common form of frame panel walls consisted simply of framing members assembled together with exterior surfacing elements. Interior surfacing was commonly field applied in order to facilitate field installation of plumbing, heating, and wiring and to simplify the application of acceptable interior finish.

It is interesting to note that two of the largest producers of houses in this category [26] (both of which combined prefabrication and site-fabrication techniques) used stucco for at least part of the exterior surface. This serves to illustrate the fact that strict rules cannot be laid down for the prefabrication process, for combinations of favorable climatic conditions, projects large enough to permit efficient techniques of application (in this case gunite), and highly organized construction systems can turn to competitive advantage even the wet processes often considered incompatible with prefabrication. It is foolish, therefore, to attempt to discover an absolute scale of values or an ideal to which various systems may be compared. It cannot too often be emphasized that design must be considered in a very broad sense, embracing the whole production and marketing scheme of the prefabricator. Nevertheless, the smallest details of design have a considerable interest of their own and are also properly the subject of consideration.

Panel size. Ordinarily the factors controlling size are the bulk and weight which can easily be manhandled in the field. With the exception of the few producers of modular panels, whose aim in brief was to produce a rather more complex variety of stock building material, there has been a noticeable tendency, not clearly reflected in the data, to use the largest panel practicable in the field, thereby cutting down on erection labor and field jointing, among

[26] Kaiser Community Homes and the Byrne Organization.

other things.[27] With this in mind, several producers had changed their 3′ or 4′ modular panels to room-size, or even wall-size, panels.

Field joints have become to most prefabricators a design problem of the greatest importance. Many of them firmly believe that vertical battens or any other external indication of joints, particularly on the exterior of the house, will be considered objectionable by a substantial part of their potential market, and some of them feel that it is important to conceal from the public the fact that the house is prefabricated at all. And it must be conceded that there has been some justification for this concern about the public reaction to visible joints.

This becomes, then, a limiting factor on the extent of factory application of surfacing materials, and many prefabricators have made a practice of leaving finish siding, facing, or shingling as a field chore in order to conceal joints. The use of room-size panels, on the other hand, offers the opportunity to conceal, eliminate, or finish with precision methods in the plant the joints of inside wall surfacing materials. It also becomes possible to reduce the exterior joints to one or two per wall and to disguise these by locating them at natural breaks in the elevation or by concealing them behind downspouts or other exterior details.

A few companies carried this a step further and produced wall-size panels, but since these usually require special handling equipment at the site, they tend to be limited to specialized situations. Nevertheless, as finishing materials become commercially available in larger sheets and as new lightweight walls are perfected (such as the plastic-impregnated paper-core sandwich walls), this trend towards larger panel size will probably continue.

Joints. A great deal of ingenuity has been exercised to develop joints[28] that will be at the same time simple to produce, hard to damage in transit or at the site, easy to erect in the field, and satisfactory in terms of performance in the final house. Refinements include joints which permit panels to be put together either way rather than only one way (such as left to right), three-way joints for places where interior partitions join exterior walls, and joints which will connect standardized ceiling, roof, and floor panels as well as wall

[27] When Harnischfeger shifted from modular to room-sized panels, considerably less framing lumber was required, as well as many fewer kinds of parts.

[28] All panel systems and many other systems require field joints. Although they are first discussed here, their applicability is in no way limited to frame panels.

panels. Of at least some importance in selecting a joint system has been the possibility of getting patents on it.

By and large, the majority of the prefabricated houses produced during the period of the survey were of wood construction, and the detailed problems of joint designs adequate for such systems need not be considered here since they are adequately discussed elsewhere.[29] The importance generally accorded the joint is so great, however, that a brief summary of the various types is presented here. These joints are illustrated in Figure 18.

A single or double lap joint is formed by the butting of contiguous skin sheets, on one or on both surfaces, over a common framing member to which one skin sheet is usually bonded in the factory and the other in the field. Such a joint is referred to in the industry as a male and female joint. The common member may, of course, be a filler strip which fits into recessed edges on both panels, and in this case it approaches a spline in character.

Batten strips can be used to join two panels which are butted together, and they usually increase the weathertightness of the joint. The batten is one of the oldest and simplest of joint methods, but there is a marked tendency to avoid it because of the belief that the general public will not tolerate such a sign of transitory character in a permanent house.

The spline is usually a continuous joint, and it is popular because it permits use of the same simple field device at either edge of the panel and because it permits flush finishing in the factory of both frame and surfacing materials—an advantage in transporting and handling and in certain manufacturing and finishing operations. This involves somewhat more millwork than the previous joints, and, since most prefabricators prefer not to nail in the spline directly through the surface skin because this means a nail head or hole to conceal, the structural tie achieved is often not so strong as in the case of other joints. The spline joint is, therefore, generally used to close vertical gaps and line up panels vertically, and rarely if ever to make horizontal connections.

The interlocking joint is the most complex type of joint, mostly used for panels having both surfaces applied and finished in the factory. It requires a dimensional precision which is not easy to realize in ordinary framing woods, and may involve extensive millwork. Because of differential shrinkage in wood, for instance, Z joints have frequently given trouble. Frequently special metal parts

[29] *Manual on Wood Construction for Prefabricated Houses,* Chapter 13.

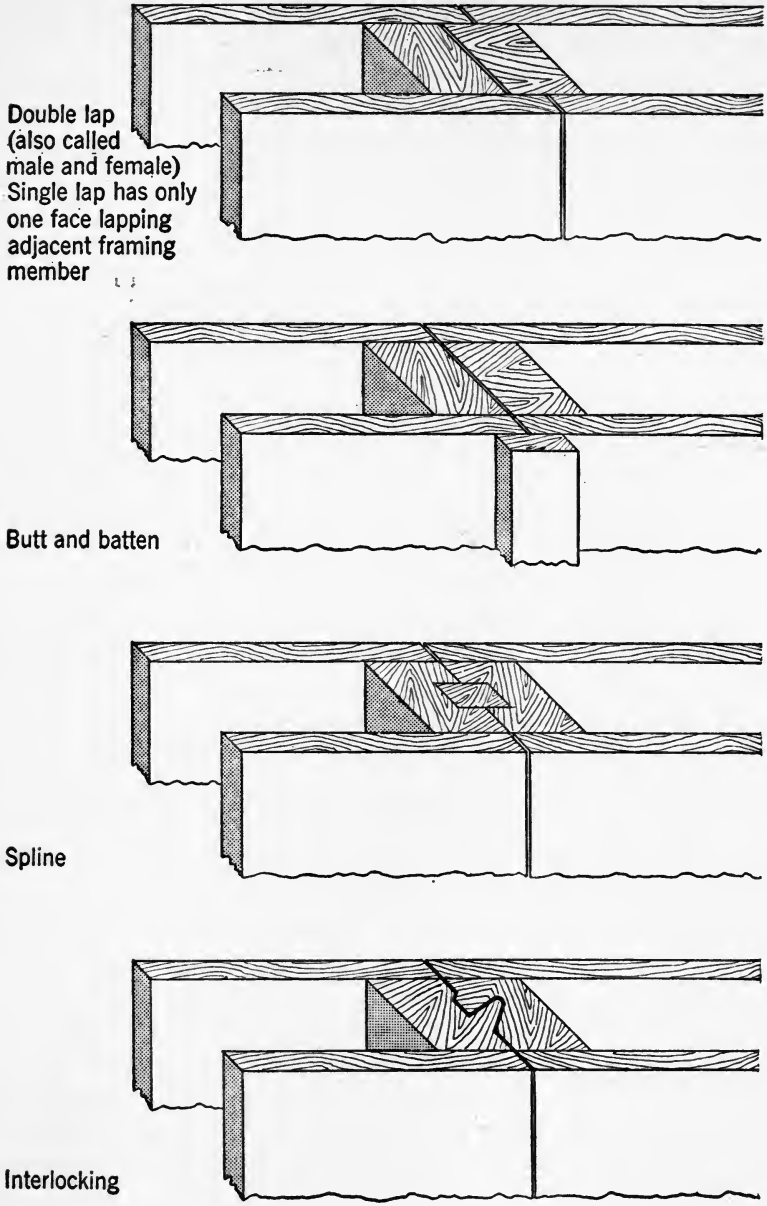


Figure 18. Commonly Used Panel Joints

are designed to speed up or improve field operation, and nearly all such joints are patented. Occasionally, these joints seem to have been designed with more proprietary pride than logic, and some seem to cause more difficulties than they solve.

Interlocking joints may have extra features, however, as when the design gives the added elasticity of permitting panels to be attached horizontally as well as vertically and thus makes possible the production of stock modular panels as a building material for assembly according to design of the local architect or builder.

Nearly all exterior joints require some sort of caulking to make them weathertight, and the ideal caulking material is still to be found. In the case of most materials the edges of the exterior surfacing itself must be carefully protected as well. Of course, where exterior joints are concealed by field-applied (or field-finished) siding or shingling, no such problem arises.

Wood frame panels. Examples of this type of construction were produced by Kaiser Community Homes (see Figure 29). A completely standardized one-story house "chassis" was produced in the factory (45% of the work) and individualized to some extent in the course of the field finishing. This chassis consisted of room-size panels made up of 2″ × 4″ studs to which ¼″ plywood was glued and stapled to serve as interior wallboard.[30] Windows and doors were fitted or hung in their frames in the walls in the plant. The panels were spiked together in the field, and chicken wire was applied over building paper as a base for the application of an exterior finish of stucco, to which areas of siding or shingling were added for variation in appearance. Interior partitions were in some cases factory-built storagewalls (entirely utilized for closets, shelves, drawers, and the like) and in some cases stressed skin panels (described in the next section). Inside surfaces were finished with a fabric-base wallpaper. At the time of the survey, about 3,000 of these houses had been built in the Los Angeles area.

Another example was the house built by the Defoe Shipbuilding Co., the walls of which were frame panels from 4′ to 12′ in width, made up of standard 2″ × 4″ studs 16″ o.c., ½″ fiberboard sheathing, and plasterboard interior surface, taped and filled at the site to present a smooth and unbroken appearance. With both surfaces factory applied, a special joint was necessary, and an interlocking

[30] Both gluing and stapling or nailing are frequently used in this way to give added rigidity and thereby eliminate much of the need of bracing in the walls and bridging in the floors. The staples or nails serve principally to apply pressure until the glue sets.

joint was used, requiring some millwork. At the site joining was accomplished by diagonal nailing from the outside, with the final joints concealed by exterior siding. Aside from the joints and the factory application of surfacing, insulation, windows, and doors, there was little to distinguish this house from the conventional wood frame house. In that sense, it was typical of a large group of prefabricated houses, more of which have probably been built and sold since the end of the war than any other type. Many of these companies, while maintaining profitable operations with this sort of house, are at the same time working on more unconventional designs for eventual production.

Metal frame panels. Houses using this type of construction were far less conventional than those we have just discussed (see Figure 19). The widely advertised Lustron house was a good case in point. Here the frame consisted of steel studs, rolled in special "hat" sections and welded 2′ o.c. on both sides of horizontal "hat" section members, with channel members welded in between the studs as bracing. Window and door framing were also welded into the panel, and the whole framing system then got a bonderizing coat and a sluiced-on protective enamel coat. The interior and exterior surfaces were steel pans finished with vitreous enamel, as were the roof and ceiling surfaces, and all were attached in the field excepting those in the special bay window section, which was factory assembled. The vitreous enamel finish was available in a variety of colors, and it offered a relatively permanent, easily cleaned surface. For heating, the house had a plenum chamber over the ceiling pans, converting these into a radiant ceiling, and insulation was factory applied to the inside of the exterior steel pans and field applied over the top of the plenum chamber. Through-metal contact and resulting condensation were minimized by continuing the insulation between the metal studs and exterior pans. Weather bond between pans was achieved by extruded gaskets of Koroseal specially designed to seal the joint between the flanges of the pans. This house was notable for the completeness of the package offered through the chain of Lustron dealers, and for the utility room offering bulk storage within the house.[31] The standard two-bedroom house was about 1,000 sq. ft. in floor area, or substantially larger than the average prefabricated house. The three-bedroom house contained more than 1,200 sq. ft.

[31] The house was basementless and had a floor of asphalt tile over concrete grade beam and slab.

Another metal frame panel house was that built in a 1,200-house project at Harundale, Md., by the Byrne Organization in a combination of prefabrication and site-fabrication techniques [32] (see Figure 28). Here Macomber-type steel studs (rolled to give a "hat-shaped" section) were used, with two opposed sections spaced by welded tie rods to make a complete wall stud. The complete studs were in turn assembled into steel frame panels in a shop at the site, a 1" glass fiberboard laid over the exterior of these panels, and a paper-backed wire mesh pinned through the fiberboard to the panels by a special welding machine for stucco finish. The paper acted as a weather barrier, and the insulation near the outside surface protected the steel members from falling below dew point and causing condensation, while two coats of special aluminum paint on plaster served as a vapor barrier. The structure was placed on a radiant-heated floor slab and stucco applied as an outside surface in the field. Initially, before the company turned to the use of aluminum paint, vapor-barrier paper with wire lath had been nailed on the inside to the frame in the shop and plaster applied in the field. Walls were vented into the roof space to assist in carrying off any vapor accumulation which might occur. Interior partitions were site assembled, and the wall panels and roof trusses were welded together at the site to form a continuous rigid frame structure, far stronger than required by codes.

A very different type of metal construction was offered by General Homes. Although this was primarily a frame panel construction, reliance was also placed in part upon stressed skin principles. The core of the panel consisted of 0.032" aluminum sheet, shaped into continuous trapezoidal sections 4" high and 6" center to center. The surface, inner and outer, was 0.032" aluminum skin bonded to ½" fiberboard sheets. This surface was screwed to the shaped core in sheets 2' o.c. through aluminum trim strips. Aluminum straps, 2' o.c. and riveted to the core horizontally, added stiffening. Panels were locked together in the field by tabs punched out of channels in the end of the panels. In the shop 4" batts of insulation were inserted into the cores, and all metal surfaces shop coated with zinc chromate primer. A simple screw attachment in the field was used to install windows in special framing prepared in the shop.

[32] The recent financial troubles of this project have caused a great deal of speculation about the principles of location, site planning, design, and fabrication used by the Byrne Organization. Needless to say, blame cannot be firmly fixed.

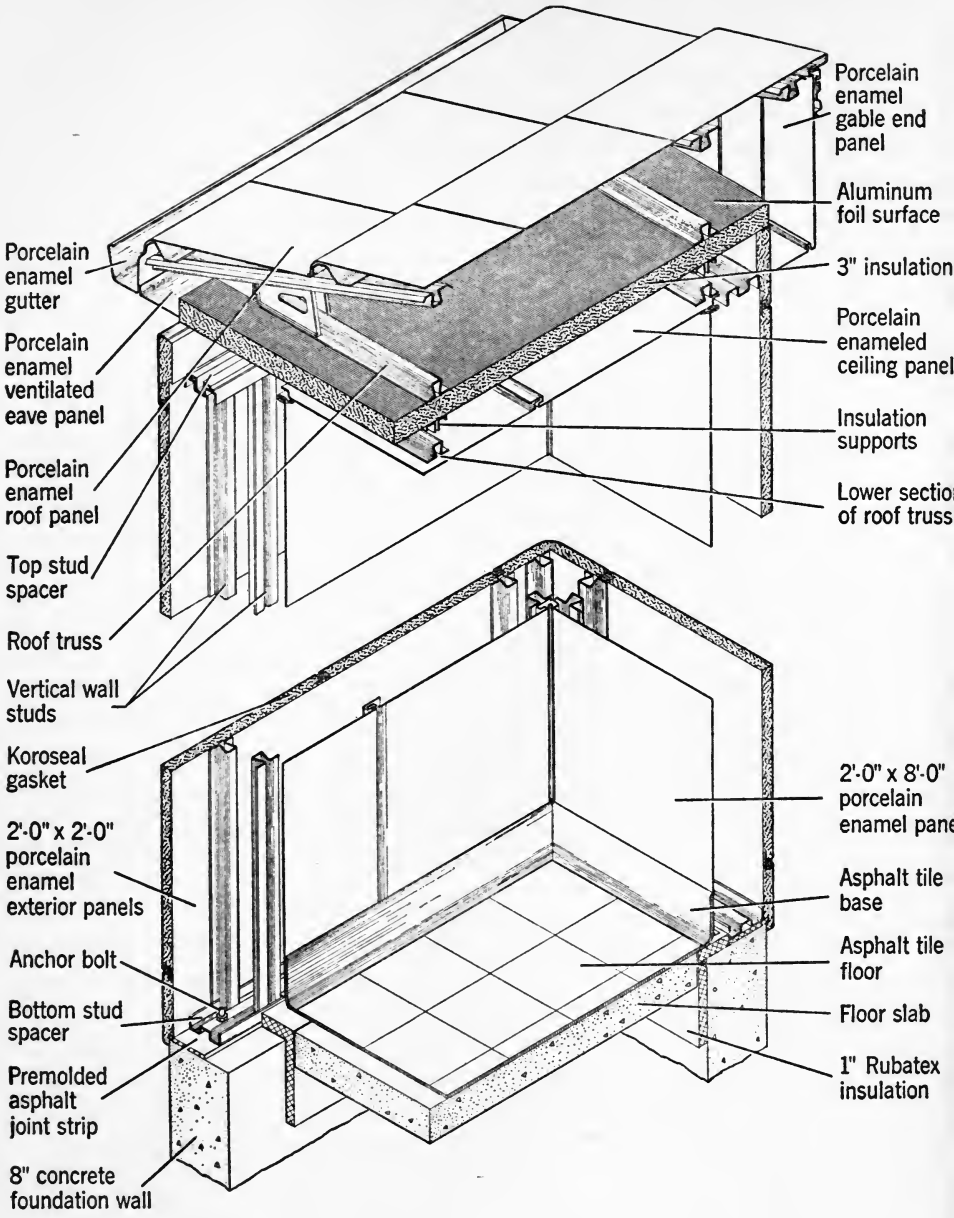


Figure 19. Metal Construction Systems: (1) Lustron

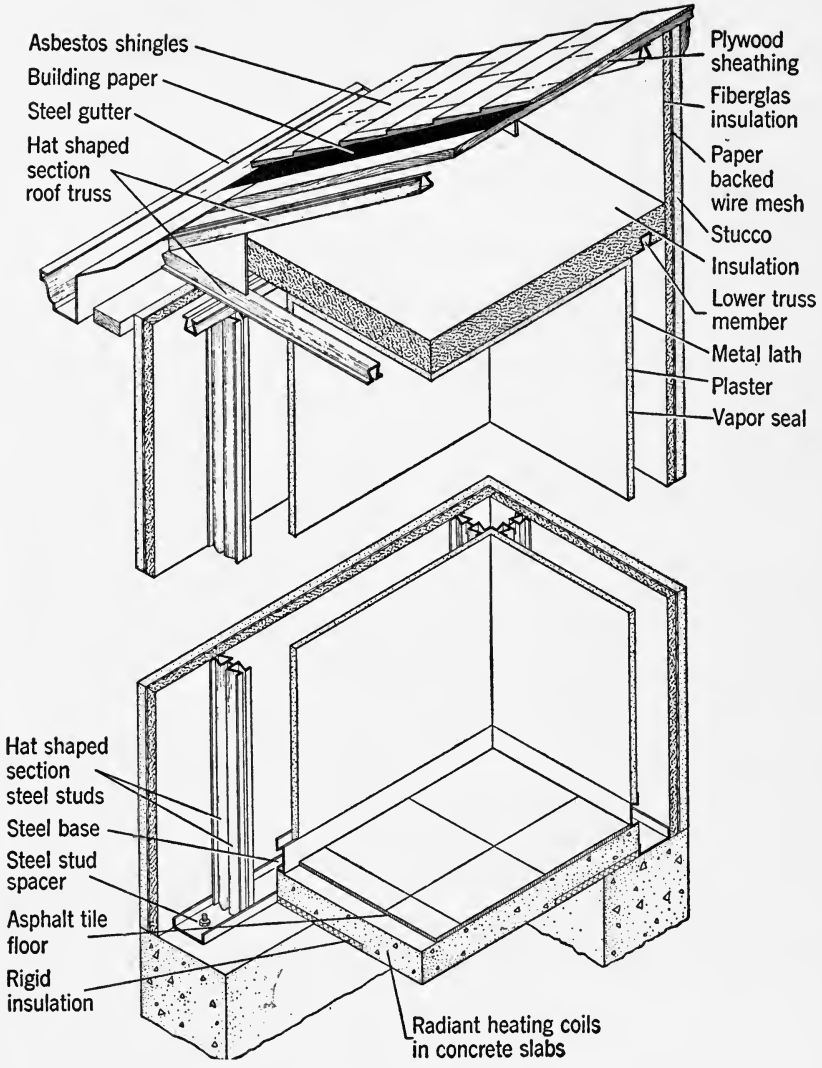


Figure 19. Metal Construction Systems: (2) Byrne Organization

Chart F gives a summary of the construction details of the 62 companies using frame panels in their walls. It will be noted at once that the great majority, 55 out of 62, used wood as their principal material, and that, of these, the great majority, 46 out of 55, used conventional 2″ × 4″ studs, 16″ o.c.

Chart **F**

Frame Panel Wall

62 Companies

Frame members	55	wood
	6	steel
	1	aluminum
	46	2″ × 4″
	6	2″ × 3″
	49	16″ o.c.
	6	24″ o.c.
	53	nailed
	5	welded
	2	glued and nailed
Panel size	22	48″
	19	room size
	7	wall size
Joint	40	butt
	7	interlock
	6	batten
Insulation	11	fiberboard
	7	batts
	6	metal foil
Vapor barrier	7	metal foil
	7	insulation backing
	4	paper

Exterior structural cladding	27	wood
	16	plywood
	9	fiberboard
	3	steel
	2	aluminum
	16	1″ (wood)
	7	⅜″ (plywood)
	6	½″ (plywood)
	49	nailed
	3	glued and nailed
	52	shop
	10	field
Exterior finish	21	wood siding
	12	wood cladding surface
	5	metal cladding surface
	32	shop
	27	field
Interior surface	16	gypsum board
	20	optional
	9	plywood
	7	fiberboard
	35	nailed
	4	troweled
	3	glued and nailed
	34	field
	27	shop

4. Stressed Skin Panels

Lumber and plywood panels. Companies using this system of construction varied the most, as a group, from conventional structural design, and they represent one of the most significant developments in the field. In all, 32 companies used plywood stressed skin panels.[33]

[33] It has been noted above that the term "stressed skin" is somewhat loosely applied to this construction, since there is some structural reliance on the framing members themselves. The Forest Products Laboratory prefers the term "stressed-cover panels" in this connection, and other terms are undoubtedly in use. "Stressed skin" is nevertheless retained for use here because the term is so widely familiar.

The general characteristics of this system include smaller consumption of material and lighter weight, compared to conventional frame systems, achieved at the same time as increased strength and structural stiffness. Basically, the system depends on the strength developed by bonding rigidly together by means of specialized gluing techniques a system of light wood framing members and thin plywood surface sheets, so that the whole acts together in the nature of a box girder. Such a panel, when correctly made, is much stronger and stiffer than conventional wood frame construction. Wall thickness can be substantially less than that of conventional construction. From the viewpoint of economy, the system not only uses less wood than conventional construction, but has the further advantage that plywood uses a larger percentage of the log than can be made into lumber. On the other hand the quality of the framing wood must in most cases be better. Research has developed waterproof, high-quality glues and improved techniques for binding the surface sheets to the framing members, and current development work on the composition and design of these sheets indicates that further improvements are to be expected in the future.

At the present time, the quality of the construction is such that the plywood surfaces can be used for interior and even exterior finish, although there is still some difficulty in maintaining good exterior finish on plywood exposed to the weather. In this respect, edge-grained plywood and the recent redwood plywood perform better, and plastic and other surface coatings further improve performance. The framing members, because of their smaller section and the need to present a flat surface for gluing, are somewhat higher in quality than ordinary framing and in some cases can be used by prefabricators as actual floor and window framing, thus vastly reducing requirements for trim in these locations.

Interior partitions are frequently of the same construction, even when not load bearing, because of the availability of manufacturing facilities, although single plywood sheets, practically self-supporting, are occasionally used in locations such as closets where the sheet is not the sole barrier between rooms.

The manner in which some of the new technical problems presented by stressed skin plywood panels have been met by the prefabricators is of interest, particularly since in many cases these problems are also faced in the use of other new materials. For that reason, a few of the most significant problems will be discussed here briefly.

Condensation. A construction which makes the wall markedly more airtight creates the benefit of diminished heat loss but also the problem of diminished vapor permeation, and therefore condensation. When the vapor originating within a house in cold weather cannot readily escape through the floors, walls, and roof (as is the case with stressed skin plywood or with metal panel walls, for example), there is always the possibility of its coming in contact with some frame or surfacing element which has been cooled by outside air to a temperature below the dew point. At the point of such contact condensation occurs, and as this point is likely to be within the wall structure itself, the resulting moisture may do considerable damage.[34] Among the prefabricators using stressed skin plywood and metal panels, at least nine were using special ventilation slots within the wall space, and many used vapor barriers designed to reduce the penetration of vapor into the wall structure from the house area.

Among the most commonly used vapor barriers were asphalt membranes laminated with kraft paper (and frequently backed by insulation) and metal foils. The performance of such barriers is good only when they are carefully fitted and tightly fastened in place. In the common examples in which the material supposedly serving as a vapor barrier was not even tacked or stapled in place, there was serious question of its effectiveness.

A problem of detail in stressed skin construction is that the heads of nails or staples on the interior surface are frequently the points at which there may be condensation, resulting in dark spots or stains. Several companies sought to solve this problem by countersinking and puttying over these heads, while others avoided it by bonding the plywood to the frame without nails or staples, through the use of glues set with hot or cold presses.

In stressed skin plywood, as in plaster and many other materials, a combination of such factors as the static charges on dust particles and the differential rate of thermal and vapor conductivity between the sheet alone and the sheet backed by framing will often result in the collection of dust and dirt in such a way as to show on the surface the pattern of framing in the form of so-called "shadow lines." Some prefabricators sought to avoid this effect by developing designs which tended to equalize thermal and moisture conductivity through-

[34] For a discussion of the condensation problems in some fifty different wood and metal wall and roof constructions tested in the Pennsylvania State College Climatometer see Ralph R. Britton, "Condensation in Walls and Roofs," *HHFA Technical Paper,* nos. 1, 2, 3, and 8 (March, June, and September 1947; April 1948).

out. Gunnison, for example, fluted the framing members wherever they came in contact with the surface skin in an effort to reduce this differential.

Insulation. The only common characteristic observed among companies in this respect was the almost complete absence of loose or fill-type insulation for walls. The common insulations were in the form of sheets, batts, or blankets, usually paper backed; and the considerations to be met in the selection of an insulating material included the ease of handling and installation, the durability, the insulative quality, and the amount of space available for storage in the plant.

Finishes. As a result of the development of waterproof glues, delamination of plies is a rare occurrence if edges are well protected, and of the 32 companies using stressed skin plywood construction in their walls, 20 used the plywood as the exterior finish material. A good deal of development work in paints and sealers has helped to make this possible,[35] although some of the good sealers, such as aluminum flake, have been little used by prefabricators because they add production difficulties.

Several of the large companies were using the relatively new device of bonding plastic-impregnated paper to the plywood to serve as an exterior surface material and an excellent base for paint. Other companies made use of striated plywood, the scoring of which tends to conceal any checking which may occur, to disguise the joints between panels, and to give a pleasantly textured finish. On interiors, where neither of these devices was used, it was common to find a rounding or beveling of the edge of the plywood sheets, in recognition of the fact that expansion and contraction of the panel surfaces will otherwise eventually make visible cracks in paint or paper surfacing anyway.

Nearly all the companies using stressed skin plywood panels without further interior or exterior finishing materials designed their houses in terms of modular panel widths of 40″ or 4′, principally because the plywood sheets come in widths of 4′, but partly also because of the tendency of larger panels to bulge as the exterior and interior sheets develop large differences in moisture content. Where additional surfacing materials are used, this tendency can be rather easily controlled.

A few of the companies prefinished the plywood interior in the shop, usually with tinted sealers and lacquers to produce a subdued

[35] See *Manual on Wood Construction for Prefabricated Houses,* Chapter 7.

grain finish. Most companies finished in the field, taking special precautions to combat the cracking of the finish materials at the joints. One method used for this purpose was taping and puttying, and fabric-based or other special wallpaper was another. Some companies used batten strips, taking precautions to avoid the opening of cracks in the finish along the batten edges which result from shrinkage and from movement of the panels behind them.

Large plywood sheets were not ordinarily used in stressed skin panels, but more usually in frame panel construction. Such sheets were made up by factory joining of $4' \times 8'$ sheets into room-size sheets by scarf or lap joining and gluing under a hot press, yielding a very satisfactory continuous wall.

This brief discussion of the technical problems of plywood will illustrate the fact that the use of the material for efficient home construction has depended in large measure upon the development of sound factory processes. In the opinion of many a prefabricator, it is definitely a prefabrication material, which could be used effectively in the field only through craftsmanship of cabinetmaker quality.

Several of the companies used laminated paper Upson board as an interior wall surface material, and at least one used it in a partially stressed skin design. Most frequently this material was used in room-size sheets, with the openings cut out of it. Designs took care to conceal cracks or unpainted lines which might appear as the result of movement of the board over the course of time. Other materials were also employed, such as Homasote, a wood-pulp board available in room-size sheets, used in one case in partially stressed skin construction.

Examples. Green's Ready-Built Homes, Ivon R. Ford, Inc., and Winner Manufacturing Company, Inc., all produced stressed skin panel houses. Green's Ready-Built Homes produced a panelized "solar house" (see Figure 30), of which much of the design was the work of George Fred Keck of Chicago. The basic panel was 39″ wide, of wall height, and composed of $\frac{3}{8}$″ exterior grade and $\frac{1}{4}$″ interior finish plywood glued (by high-frequency induction hot press) to a frame of $2'' \times 3''$ edge members supported by two $1'' \times 3''$ intermediate studs. Panels were held together by metal connectors on the grooved and beveled panel edges, the connectors being held firmly by the position of the heads of screws attached to the intersecting edge of a partition or corner panel (and also to battens, which were inserted at each joint). This gave the system a feature of demountability. Between the plywood surfaces two aluminum-

foil reflective layers were carefully bonded in such a way as to create three separate and approximately equal insulating air spaces within the panel. Exterior surfaces were sealed, primed, and finished with oil paints, and interior surfaces were shop finished with clear stain and lacquer or paint, as required. At the site wall panels were positioned in an extruded aluminum plate. A feature of this house, and one which was beginning to appear elsewhere also, was the use of fixed and sealed double panes of glass for vision, with separate wood panel openings top and bottom, louvered and screened, for ventilation. This design permitted the use of larger windows without the expense of the complex carpentry often encountered in movable sash construction. The house had a high degree of factory finish, and the finish was of a quality which would be expensive to duplicate in the field. In architectural planning the house was also unconventional, with an attempt to give all rooms due south orientation.

Ivon R. Ford, Inc., and its nine licensees spread over the United States and Canada manufactured stressed skin plywood houses (see Figure 35) made up from room-size panels of $\frac{3}{8}''$ exterior sheathing and $\frac{1}{4}''$ interior finish plywood glued and nailed to $2'' \times 3''$ studding 16″ o.c. Doors and double-hung windows were factory installed. Joints, of male and female type, were glued as well as nailed, and siding or shingling was applied over the plywood sheathing, in the field. The bottom plate of the wall panel was rabbeted into the sill for alignment and fastened in place by toe-nailing into the sill with spikes. The design was relatively conventional and simple, and yet would be difficult to produce in economical quantity without a well-equipped woodworking shop.

The Winner Manufacturing Company at the time of our survey produced the Shelter Industries House, designed by Donald Desky. Room-size panels were made up of $\frac{3}{8}''$ striated exterior plywood and $\frac{5}{16}''$ striated interior plywood bonded to $1\frac{1}{16}'' \times 3\frac{1}{2}''$ studs 16″ o.c. Joints required to make up plywood sheets of the required size were factory caulked. Double aluminum-foil sheets and one vapor barrier were suspended in the wall to give a total of four interior air spaces. Field joints were of the male and female type, nailed and caulked. Doors and double-hung windows were factory installed, and the striated plywood finish was field finished with lacquer or paint as desired. This house was of unconventional architectural as well as structural design.

Metal skin panels. This type of construction was used by the Butler Manufacturing Company which made a house (see Figure

36) of 2′ wide aluminum pans of wall height which acted in the manner of vertical channels, flange to flange. The web of the channel served as the exterior surface of the house, and in structural action constituted a stressed skin 0.051″ thick. The 4″ flanges gripped wood filler strips which cut down the thermal conductivity from outside to inside. In part, also, these filler strips served as a frame, and they provided a wood surface for the nailing of optional interior finish materials. Two braces per panel stiffened the flanges, and the panels were clipped together at the site with an H-shaped key, driven home by a hammer. Blanket insulation was added to the reflective insulation provided by the aluminum surfaces themselves, and panels were ventilated to the outside to minimize condensation and obviate the necessity of a vapor barrier. Window sash and frames were of extruded aluminum sections, and doors and door frames were of wood. Shorter lengths of panel were used under and over openings and to make up gable ends. Aluminum channels positioned the panels top and bottom and were bolted into the floor and ceiling; wood molding and base were used on the interior. Exterior finish was paint applied as desired in the field over shop-applied zinc chromate primer.

Plastic-impregnated paper-core materials (see Figure 20). One of the most interesting technical developments in the postwar period, this construction was originally a development of the aircraft industry. Used because of their high strength/weight ratio, such materials have been the subject of a great deal of interest and investigation on the part of the prefabricators. Usually classified as sandwich construction, they are generally most like the stressed skin construction of those classifications which are used here. The two forms most commonly seen at the time of our survey were the honeycomb paper core and the corrugated paper core.[36] Development work on the former was carried on primarily by Lincoln Houses Corporation, Chrysler, Douglas Aircraft, and Consolidated Vultee; while the latter has been developed primarily by the U. S. Forest Products Laboratory.

At the time of the survey, Utley-Lincoln planned to make a house with panels of the Lincoln core and aluminum skins bonded by the Chrysler method. Southern California Homes was starting production on a house of similar basic material, and it is an indication of the structural advantages of this development that, for southern California climatic conditions, a wall section only 2″ thick required no further insulation.

[36] Described in more detail in Chapter 9.

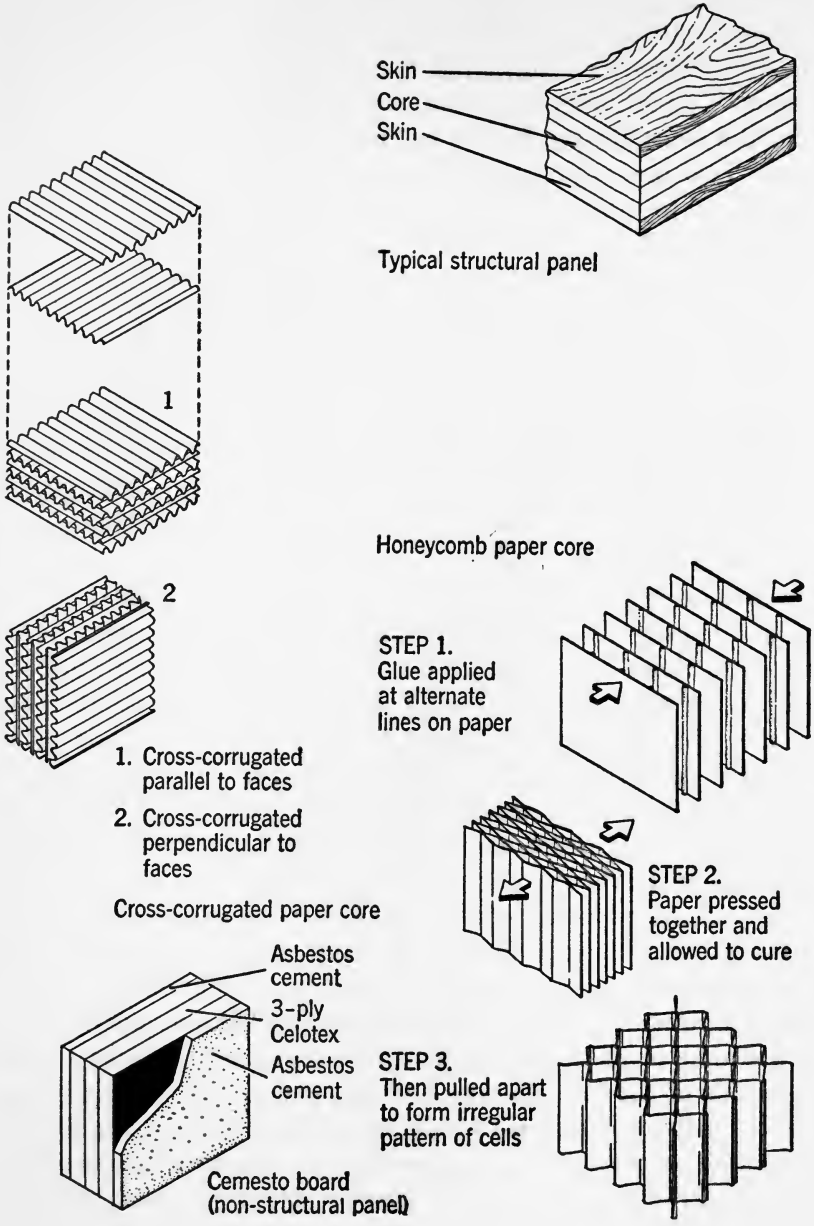


Figure 20. Sandwich Panel Materials

The Southern California Homes system included a semihoneycomb paper core, impregnated with phenolic resin, and faced with aluminum skins (3S, 0.020″ thick, ¾ hard) in room-size panels. Panel edges and openings were formed by channels of aluminum 0.064″ thick, the flanges of which were bonded between skin and core materials. The bottom edge of the panel was bonded to a 2″ box section of aluminum which served as a wiring conduit and also provided access every 4′ for bolting the panels to the foundation slab. On the inside this was covered by a simple baseboard. Aluminum rolled strip door and window stops were screwed to the channels, and served to locate steel casement sash and paper-core wood-veneer flush doors. On the outside the bottom edge of the panel had a lip to cover the exterior joint at the edge of the foundation. From the top edge of wall panels, bolts passed through to roof panels and held them in place. Paint over zinc chromate primer was the finish. This wall, complete, averaged only 1 lb. per sq. ft. Architecturally, the house was of unconventional design and reflected an appreciation of the possibilities of the new material. It would require a few changes, however, particularly to avoid through-metal in the walls, for use in northern climates.

Steel skins, particularly stainless steel, could of course be used as well as aluminum in paper-cored walls, but as yet no prefabricator had tried them. There was during the time of the survey, however, at least one house making use of plywood-faced paper-core walls. This was the Acorn House, designed by Carl Koch and John Bemis. Here the design called for a core, not of the honeycomb type, but made up of corrugated paper with the direction of the corrugations alternated for good performance structurally and as insulation, according to the recommendations of the U. S. Forest Products Laboratory. The core was then bonded in a press to surfacing sheets of ¼″ interior grade plywood and ⅜″ striated exterior plywood. Advantage was taken of the lightness of the material to design a house of 800 sq. ft. which could be put together in the factory around a completely equipped kitchen, bathroom, and utility core, folded into a compact 9′ × 24′ unit, shipped to the site on an ordinary trailer, and there set on posts and unfolded in a very simple operation to produce the finished house. Folding was made possible by simple hinged joints sealed with neoprene gaskets. This house, light as it was, was designed for use in northern climates.

The development of these new lightweight materials has made it possible to assemble larger and larger sections, thus avoiding the field joint and site labor problems. This tendency in turn has brought

with it trends towards a greater degree of standardization in the final house, in order to make possible simple and repetitive factory operations, and towards a highly integrated design for the whole house which assures full benefit of the thermal, structural, and acoustical properties of the new materials and careful attention to technical possibilities and difficulties.

Chart **G**

Stressed Skin Panel Wall

41 Companies

Frame members or structural core	37	wood
	2	aluminum
	1	steel
	1	plastic-impregnated paper
	16	2″ × 3″
	10	2″ × 4″
	4	2″ × 2″
	27	16″ o.c.
	3	8½″ o.c.
	2	12″ o.c.
	22	glued and nailed
	9	nailed
	5	glued
Panel size	16	48″
	16	room size
	3	40″
Joint	12	m and f
	6	spline
	5	butt
Insulation	14	batts
	7	blanket
	7	metal foil

Vapor barrier	10	insulation backing
	5	spray or brush coat
	4	metal foil
Exterior structural cladding	32	plywood
	3	wood
	3	fiberboard
	2	aluminum
	1	steel
	16	⅜″
	9	¼″
	3	½″
	25	glued and nailed
	4	electronic glue
	3	hot press glue
	2	nailed
	39	shop
	2	field
Exterior finish	20	plywood cladding surface
	6	wood siding
	4	metal cladding surface
	26	shop
	15	field
Interior surface	32	plywood
	4	gypsum board
	3	aluminum
	27	glued and nailed
	4	electronic glue
	3	hot press glue
	2	nailed
	39	shop
	2	field

Chart G gives a summary of the structural details used by the 41 companies which were, at the time of the survey, making use in their walls of stressed skin panels in some one of the many forms which have been considered.

5. Solid Panels

Precast concrete. The solid panel wall, as the term has been used here, is a wall in which the structural loading is spread throughout a more or less homogeneous panel system. The most common design falling within this classification is the "precast concrete" wall, of which there were 12 types under development at the time of the survey. At the time, very few were in production, and none on a large scale, although wide interest was evinced in their possibilities.

Some of the disadvantages of concrete for this purpose have already been mentioned on p. 183. Of these, perhaps the greatest is the combination of weight and bulk with frangibility at the edges, although the designer must also deal with poor thermal insulation and with the problem of obtaining an adequate degree of accuracy for any complex concrete shape at the same time as production and erection economy. Lightweight aggregates and foamed concretes offer a potential saving in weight and an improvement in thermal insulation, but relatively few prefabricators were making use of them. Indeed, most concrete systems were designed for relatively simple and unfinished houses in relatively warm climates.

The hollow slab is, of course, a partial answer to the problems of heavy weight and poor thermal insulation, but it is also much more difficult to precast than a solid slab. For low cost, the Portland Cement Association suggested precast ribbed slabs, and a few of the prefabricators used them. In most precast concrete systems, care was required to provide thermal insulation and to avoid condensation, particularly along the joints where there was likely to be through-concrete. At the joints, also, provision had to be made for expansion and contraction in the heavy concrete masses, and for the problems of displacement and poor alignment resulting from inaccuracies or changes in dimension or shape along the slab edges. An elastic joining material of relatively great thickness usually was employed for these reasons. It was also necessary, in most cases, because of the weight and bulk of the panels, to use additional reinforcing material to protect them during the various handling operations from casting to final placing.

Nevertheless, precast concrete slabs offered certain definite advantages, such as overall design simplicity and resistance to combustion, corrosion, and insects. Development of simple casting processes, of concrete aggregates permitting easier handling and simpler

design, and of more effective joint details may well bring further concentration on concrete in the next few years.[37]

An example of a precast concrete house was that being developed by Merriam and Twachtman at the time of the survey. Wall panels of room size, as large as 8′ × 20′, were to be precast of a vibrated concrete incorporating an expanded slag aggregate, and given an exterior surface of white cement which was supposed to require no further painting. The interior surface was to be a factory-applied plastic-base paint intended to serve as a vapor barrier as well. Reinforcement was to be provided by wire mesh and by bars tightened together at vertical joints to tie the panels together and hold them in proper alignment. Thick strips of rubber mastic were to be used at all joints, allowing for imperfections and cutting down acoustic and thermal transmission; door bucks composed of metal sills and jambs were cast in at the time of making the sections, and exterior wall joints were to be protected by precast pilasters.

Other precast concrete systems were quite different in concept; for example, there was the "Pfeifer Unit" produced by The U. S. Housing Materials Corporation. This was small (24″ × 24″) and served the function more of a building block than of a true wall panel. The most familiar example of the building block, of course, is the standard concrete block, made by simple machinery and available in every part of the country. Probably neither block should really be classed as a wall panel.

Composite materials. These may also come under the heading of solid panel walls. Cemesto Houses have already been described under frame and curtain wall assemblies, but the use of a similar board as a load-bearing panel without structural framing has also aroused some interest, although it would require a tougher skin material and careful attention to the joint and to the waterproofing of

[37] The work of Corwin Willson on concretes of extremely varying characteristics was reported during World War II. Willson tested 8,000 specimens from 225 materials, which included organic and mineral wastes of all sorts in combination with a variety of fillers, leaveners, stabilizers, waterproofers, and surface coatings. He found potentially useful combinations composed of common wastes, and he was able to secure many concretes of excellent characteristics for building construction. The possibility is thus presented that even a manufacturer of wood houses may make extensive use of his waste products for such purposes as floor tiles, wall coverings, piers, slabs, or other building components not now supplied in his house package. (Corwin D. Willson, *Properties of Assorted Light Weight Aggregate Materials*, Office of Production Research and Development [Washington, 1944]. Also available from Hobart Publishing Company, Washington, D. C.)

Solid Panel Wall

12 Companies

Frame members or structural core	8	concrete
	3	steel
	1	aluminum
	4	6″ thickness
	2	4″ thickness
	8	poured
	3	bolted
	1	glued
Panel size	5	room size
	5	48″
Joint	6	butt
	3	tongue and groove
Insulation	4	insulating concrete
	2	loose
Vapor barrier	2	spray or brush coat
	1	membrane
	1	metal foil
Exterior finish	6	concrete cladding
	3	stucco or concrete
	6	shop
	5	field
Interior surface	4	cement concrete
	2	lath and plaster
	2	gypsum board
	7	field
	5	shop

the panel edge, since the Celotex filler of the Cemesto sandwich loses as much as 80% of its shear strength when it is wet.

Another familiar composite which may eventually be used in this way is the panel of wood chips bound with cementitious materials. This has been experimented with for years, and such a panel was being manufactured for industrial insulation by the Porete Mfg. Co. under the name of Porex. Durisol, originally manufactured in Switzerland and widely used in Europe, is a similar product recently made available in the United States. Material of finer wood filler and denser composition was proposed by Newark Industries of Ohio. These compositions, although simple to prepare in small amounts, present a very difficult mechanical problem of mixing and handling for continuous strip production, and many of them can be thoroughly protected against moisture only through the exercise of great care. They were not in use for prefabrication purposes at the time of our survey.

Chart H presents construction details of the 12 companies making use of one or another of these solid panel walls when our survey was made.

6. Poured at Site

While this construction is not prefabrication, as we ordinarily think of it, some mention should be made of industrialized systems which, through design and factory fabrication of standardized forming and pouring equipment, amount almost to prefabrication. In their most extreme development, as in the LeTourneau house, such systems achieve mechanization and standardization comparable to those of the most standardized factory-built houses.

Hundreds, and perhaps thousands, of systems for more efficient site pouring of concrete walls have been developed, and from the start it has been apparent that ease of forming is of paramount importance. One of the simplest solutions has been the so-called "tilt up" system, in which the walls are cast horizontally, often directly on the floor slab and sometimes in tiers one on top of the other, and then tilted up into vertical position by various ingenious mechanical contrivances. Use has been made of wood blocks during pouring to position the reinforcement and in the finished wall to serve as nailing blocks. The potential savings over vertical casting are obvious. Important work

on systems of this sort has been done by the Portland Cement Association, by E. J. Rappoli, F. N. Severud, and many others.

Hal B. Hayes, producer of the Hayes Econocrete House, has done a great deal of work on the West Coast on industrialized collapsible forms for standardized houses, including withdrawable cores for cavity wall construction. However, at the time of the survey, he was more interested in factory precasting, in lightweight waterproof concrete, of solid wall and roof slabs 2½" thick and room size, with interlocking corners and tongue and groove joints.

A mixed-material system, studied shortly after World War II by A. J. Higgins, made use of chemically foamed insulating concrete poured at the site into permanent "forms" of vitreous enameled steel which served as surface finish. In later development work, Higgins abandoned the steel surfaces and was at work on the design of a house using only site-poured foamed concrete slabs.

One of the most ingenious systems, in terms of structural efficiency, was that of the Neff Airform house. This was not prefabricated, but made at the site of gunite (concrete) sprayed on light wire-mesh reinforcement which had been laid over an inflated rubberized-fabric form. The resulting structure was a monolithic monocoque which could be hemispheric, ellipsoidal, or semicylindrical in shape, and its efficient use of materials and form offered many potential cost savings. Neff produced many houses, mostly abroad, but there were difficulties in carrying out his system, particularly in construction controls and in making window and door openings and connections between shapes of this sort.

The LeTourneau system was one of the most elaborate house-casting schemes to be commercially marketed and developed.[38] It involved the use of a special forming system and a tremendous machine, the Tournalayer, which could pick up a monolithically cast house, carry it to the site, and position it there for final finishing (see Figure 37).

Another site-poured system of considerable interest was that of the Ibec Housing Corporation (see Figure 38). This system, designed to apply mechanical processes to large-scale concrete construction of houses, used heavy lifting equipment and a unitary set of wall forms. These forms, operated by levers and having nylon-rubber corners to speed up and facilitate stripping and resetting, were used on a 24-hour cycle. Roof slabs were poured on the ground in stacks, pancake fashion, thus requiring only edge forms and per-

[38] This system is fully described in Chapter 9.

mitting the top surface of each slab to act as the form for the succeeding slab. After the form for the walls and partitions had been lifted, the roof slab was picked up and set in place by a vacuum lifting mat. Ibec used lightweight aggregates for wall and roof construction where climatic conditions required an insulated wall.

It should be noted in connection with these various systems that, in the first place, all have their most likely application in large projects and, in the second place, all require a great deal of finishing work at the site, often by handicraft methods, to produce a house having the heating, lighting, and mechanical standards common to this country. In warm climates particularly, and in special circumstances of urgent need for shelter or lack of other housing materials, however, these systems have already proved their usefulness and offer real advantages.

7. Windows and Doors

One of the important considerations in the prefabrication of walls has little to do with the structure of the wall section itself; this is the problem of windows and doors. In the course of the earlier discussion, reference has occasionally been made to the manner in which windows and doors are incorporated into the walls. Here attention is turned to the methods of fabrication of these elements.

There was an increasing popularity of metal windows, in wood as well as metal construction. This was largely because of the superior dimensional stability of the metals, which helps to give an accurate and lasting fit. However, at the time of the survey, the metal windows, particularly aluminum, were higher in initial cost than the wood windows and were able to compete principally because of dimensional stability and the possibilities of lower overall cost of maintenance. Undoubtedly design factors, consumer preference, and stability of supply also affected the choice. Counteracting these advantages were the problems of condensation on frames and sash, particularly on frames in the wall interior, and of substantial heat loss through the metal frames.

Windows have long been prefabricated by specialty companies, as have doors. At least seven of the prefabricators had developed new window designs, however, to fit their particular houses and manufacturing operations; although they rarely produced these windows, they usually helped to pay certain costs of tooling up, such as the

cost of an extrusion die for an aluminum window. Particularly when the wall section was thin, there was an effort to cut down the section of the windows by having the glass slide or roll without any enclosing sash in a frame carefully designed to avoid stress concentrations on the glass. This usually required better-quality glass and special attention to details, however, and therefore did not give lower final costs.

Many of the manufacturers, particularly those using frame panels, tended to omit weatherstripping as such from wood window construction, although some used metal sash guides and thereby obtained some weatherstripping action. The metal windows were usually designed to give full weatherstripping action.

In the case of doors, there was a definite trend towards the use of lightweight composite doors with various types of grids for cores, including plastic-impregnated paper. Such doors were especially common among the makers of stressed skin plywood panels, for they are just another form of stressed skin plywood or sandwich panel. At least one of the prefabricators in this group regularly used the plywood cut-outs from the door openings in his wall panels to make up flush doors with light wooden grid cores on his own presses.

One development in this connection which deserves mention was the use by the Lustron Corporation of sliding doors in most interior locations in its house. Such a door, designed to be foolproof, has obvious advantages in the saving of space, and public reaction to it in the Lustron houses seems to have been favorable. Made up as a part of a storagewall system of interior partitions, this may be the first of a number of such doors to appear in prefabricated houses.

E. Ceilings

1. General

The ceiling is one element of the house which should lend itself readily to mass production because of its large unbroken surface, and which should be prefinished more accurately and easily in the shop than in the field. The elimination of the awkwardness and difficulty of conventional ceiling construction is a natural goal for the prefabricators.

Furthermore, the ceiling offers to ingenious designers an opportunity for improvement of house performance with respect to acoustics, lighting, and heating. Many heating engineers and physiologists have argued that the best position for radiant heating is in the ceiling surface, despite the fact that other considerations have led to the installation of most radiant heating systems in the floor at the present time. Modern lighting experts are turning more and more attention to the overall luminous ceiling; acoustics experts have long recognized the overwhelming importance of the ceiling for control of sound. While in some respects these goals may be opposed to one another, they offer a special opportunity and a challenge to the prefabricator.

Structurally, one of the most important considerations regarding the ceiling design is the usual code regulation limiting maximum deflection. Few prefabricators use plaster, which is ordinarily allowed a maximum deflection of $\frac{1}{360}$ of the span, while many use dry finishes which are allowed maximum deflections up to $\frac{1}{240}$.[39] Further, the dry finishes reduce dead load and thus permit further reduction in the framing members supporting the ceiling. This saving is well enough understood by the prefabricators, and they have fought to have such construction allowed in building codes.

Other considerations, of course, are the possibility of hanging an extremely light ceiling from the roofing frame; the possibility of using as the ceiling merely the underside of the roof construction system, as would be the case in many flat-roof schemes; and the possibility of designing the roof structure to be supported only on exterior walls, leaving the ceiling surface unbroken by load-bearing partitions.

For the most part, it will be seen that the prefabricators were conservative in their thinking on these matters, with the exception of the last. The bulk of the designs were quite conventional, and, as a result, the ceilings were often the least prefabricated components in the house.

2. Frame Assembly

At the time of the survey, 44 companies used frame assembly systems in constructing their ceilings. In 23 cases, the frames which supported the ceiling were also the bottom chords of the roof trusses;

[39] *Prefabricated Homes,* Commercial Standard CS125–47, p. 11.

Frame Assembly Ceiling

44 Companies

Frame members	38	wood
	5	steel
	1	aluminum
	21	2″ × 6″
	8	2″ × 4″
	6	2″ × 8″
	22	16″ o.c.
	16	24″ o.c.
	31	nailed
	7	screwed or bolted
	30	field
	14	shop
	39	part of roof construction? no
	4	yes
	23	bottom chord of truss? yes
	18	no
Surface element	15	gypsum board
	8	plywood
	7	lath and plaster
	6	optional
	3	fiberboard
	26	nailed
	6	troweled
	1	screwed or bolted
	44	field
	0	shop
Insulation	5	batts
	4	loose
	2	metal foil
Vapor barrier	4	metal foil
	3	backing of insulation
	2	asphalt membrane

this left for field application only the surfacing sheets themselves, and, because in most cases the roof trusses were preassembled, field application of surface components was probably the only practical answer. Room-size or house-size ceiling sheets would be too difficult to handle under these conditions, and among the most satisfactory materials used was regular gypsum board.

A good example of unconventional ceiling construction of the frame assembly type was that of the Lustron house, in which vitreous enameled steel pans were screwed to the bottom of the doubled lower chord of the roof truss. Above this, and fastened to the upper member of this doubled lower chord, were sheets of insulating fiberboard, topped by heavy insulation. The area between the two surfaces thus became a plenum chamber which was used to heat the house, with the steel ceiling pans serving as a radiant heating panel. Heat was directed throughout the plenum by a sheet-metal baffle system. This was a most ingenious way of taking advantage of the characteristics of the Lustron construction system to produce up-to-date heating; from the point of view of the prefabricator the troubles with it were the amount of site labor required to put together with sufficient tightness the many elements of this plenum chamber in the difficult working area formed by the chords of the roof trusses, and the risk of high heat loss if this work were not well done.

The details of the construction of frame assemblies used by the prefabricators in their ceilings are summarized in Chart I.

3. Frame Panels

The use of frame panels in ceilings is complicated by the difficulties of installing vapor barriers and insulation and of getting tight, good-looking joints which are proof against the soiling action likely to result from the passage of air from the attic space. Nevertheless 54 of the companies in our survey used such ceiling panels in one way or another, and the summary of the details of their construction systems is presented in Chart J.

The difficulties with joints have led in general to simplification of ceiling panel joints and the use, in many cases, of simple lap joints between ceiling surface sheets over a single solid framing member. Where a regular butt joint was attempted, there was almost no way to allow for such shrinkage of surface sheets as might have taken

place even before installation of panels—other than by the use of battens, and these were generally felt to be unpopular with the purchasing public. Several of the companies had attempted to panelize such frangible surface materials as gypsum board, but many more of them used plywood for this purpose.

Chart **J**

Frame Panel Ceiling

54 Companies

Frame members	44	wood
	7	steel
	2	concrete
	1	aluminum
	18	2″ × 4″
	18	2″ × 6″
	4	2″ × 8″
	33	16″ o.c.
	9	24″ o.c.
	1	8½″ o.c.
	33	nailed
	9	glued and nailed
	6	welded
	51	shop
	3	field
	46	part of roof construction? no
	8	yes
	39	bottom chord of truss? no
	15	yes
Panel size	11	4′ × 12′
	5	8′ × 12′
	2	4′ × house width
	2	room size
Joint	25	butt
	6	m and f
	6	interlock

Surface element	23	plywood
	14	gypsum board
	7	fiberboard
	4	lath and plaster
	26	nailed
	15	glued and nailed
	4	troweled
	2	electronic glue
	36	shop
	18	field
Insulation	16	batts
	4	loose
	4	metal foil
	4	fiberboard
Vapor barrier	6	insulation backing
	4	metal foil
	3	asphalt membrane
	3	spray or brush coat

Experimental panels of this sort were designed by the Crawford Corporation, using ¼″ plywood in 4′ × 12′ sheets made up in a panel with the ceiling joists, and having an impermeable reflective insulation installed in the plant. A design feature was the use of steel straps to tie these panels together over the center bearing partition, to tie the panels to the rafters, and to position the structural elements before nailing.

4. Stressed Skin Panels

Because of the excess strength inherent in the stressed skin panel, it is generally used for the ceiling only when it also serves as the roof or as a second floor designed to carry live loads. In these circumstances it offers some advantages in the reduction of dead loads, and in fact it may be more appropriate than on the first floor, where there is rarely any advantage in a smooth undersurface.

However, it is difficult to avoid irregular-appearing joints between such panels without using special batten or jointing strips, unless the complete ceiling for each room area is made up as a single panel.

Stressed Skin Panel Ceiling

21 Companies

Frame members or structural core	16	wood
	2	aluminum
	2	plastic-impregnated paper
	1	steel
	5	2″ × 6″
	3	2″ × 4″
	2	2″ × 3″
	10	16″ o.c.
	2	12″ o.c.
	2	8½″ o.c.
	12	glued and nailed
	2	hot press glue
	2	nailed
	2	screwed or bolted
	2	electronic glue
	19	shop
	2	field
	11	part of roof construction? yes
	10	no
	17	bottom chord of truss? no
	4	yes
Panel size	4	4′ × 12′
	2	4′ × house width
	2	40″ × 10′ or 6′8″
	2	4′ × 4′
	2	4′ × 8′
	2	8′ × house width
Joint	5	butt
	5	"v"
	3	spline
	2	m and f
	2	interlock

Surface element	14	plywood
	4	aluminum
	2	gypsum board
	1	steel
	13	glued and nailed
	2	hot press glue
	2	nailed
	2	electronic glue
	2	screwed or bolted
	19	shop
	2	field
Insulation	5	batts
	2	metal foil
	2	reflective paint
Vapor barrier	2	spray or brush coat
	2	insulation backing
	2	asphalt membrane
	2	metal foil

In the Wingfoot home there is a single stressed skin plywood roof panel which also serves as a ceiling for the entire center section of 8′ × 26′. (The house also has two small bedroom extensions.) This ceiling is made of ¼″ plywood, sealed, primed, and finish coated in the plant and glued and stapled [40] to the underside of 1″ × 6″ and 2″ × 6″ ceiling-roof joists. The interior of the panels contains a vapor barrier and 2″ blanket insulation, and the exterior surface is ⅜″ plywood.

In the Southern California Homes house, ceiling-roof panels as large as 8′ × 18′ are made up of 3″ plastic-impregnated paper core to which are bonded sheets of 0.020″ aluminum. Exterior joints between contiguous panels are closed by an aluminum cover strip which fits over standing edges on the panels.

A summary of the details of the various types of stressed skin ceiling panels used by 21 prefabricators at the time of the survey is given in Chart K.

[40] Some authorities have questioned whether stapling gives enough glue-line pressure for a good bond in stressed skin construction.

5. Solid Panels

Almost every solid ceiling panel being produced at the time of the survey was a concrete slab used in a concrete structure, though there were designs under development making use of Cemesto-like sandwiches and similar materials. The concrete panels were relatively massive and generally required specialized equipment to lift them into place and a very strong wall structure to support them, so that their application was necessarily somewhat limited.

In this category, however, should probably be included precast spanning units of reinforced concrete,[41] even though they ordinarily are made with a hollow core. Such units come ordinarily about 1′–2′ in width, with length and thickness varying according to the requirements of span and loading. In place, the units are grouted together and present a flat concrete surface, the underside of which often serves as a ceiling. The use of prestressed concrete systems in housing applications was also under study, but none were used for specific prefabrication applications at the time of our survey.

All of the seven companies producing solid panel ceilings designed them to be used as ceiling-roof or ceiling-second floor combinations. The joints usually consisted of a lapping or keying system with a mastic filler, although Vacuum Concrete utilized a vacuum form to cast the joints at the site and give them high early strength. This company was also engaged in studying the use of prestressed concrete slabs, so designed that tensioning of the reinforcing rods in the slab after setting would throw the concrete into continuous compression and thereby stiffen the slab and increase its strength, perhaps as much as three times, without increasing the amount of material used.

6. Poured at Site

The rigid structures of the LeTourneau house, the Ibec house, and the Neff Airform house were the only ones which could be placed in this category at the time of the survey. However, work was being done at that time on cast-at-site ribbed concrete ceiling slabs, and on a number of other systems which cannot properly be called prefabrication. Of these, among the most interesting were those which used the floor slab as a form for the ceiling slab. In one of these, developed

[41] As made by The Flexicore Co., Inc., Illinois-Wisconsin Concrete Pipe Co., Cities Fuel and Supply, and others.

simultaneously by Philip N. Youtz and Tom Slick, the reinforcement pattern of the ceiling-roof slab was designed to permit the pouring of this slab around properly located metal columns which contained jacking devices. After the slab had set, the ceiling-roof could be jacked to the proper height and fixed in position, leaving nothing but curtain walls to be supplied to close in the house.

It was in these fields of concrete design, handling, and erection, rather than in true prefabrication in concrete, that some of the most interesting research and development work was being done at the time of the survey.

F. Roofs

1. General

In most cases the roof is one of the most difficult of the house components to prefabricate although, as a relatively simple and unbroken large area, it should lend itself to mass-production methods. The main difficulty, of course, is the application of final roof surfacing, which in most cases must be done in the field to ensure weathertightness. Joints on the roof surface are difficult to make secure, and, in fact, of all the elements of the house subjected to weathering, the roofing is likely to be the least durable. The development of a good inexpensive roofing scheme is still one of the great needs in the field of building construction.

With regard to flat versus pitched roofs, many of the more experienced prefabricators agreed that it was cheaper (estimates were given varying from $150 to $500) to produce a flat- than a pitched-roof structure, partly because of savings in surface area and partly because of the elimination of gable-end walls. Yet many of these prefabricators felt that it became impossibly expensive to assemble a satisfactory protective surface on a flat roof, and that pitched-roof construction retained several other advantages in the prefabrication of houses, particularly if it could provide bulk storage area and space for future expansion. In the future, the improvement of metal roofing skins may alter this balance. General Homes, for instance, had designed a roof of factory-bonded aluminum skins with special joints to be made in the field, which eliminated further field roofing work.

(The company was required to change to a pitched roof by FHA, nevertheless, at a cost estimated by its chief designer at $500 per house.)

A design idea which had been studied by several of the prefabricators (Production Line, Fuller, Southern California) was that of sealing the entire roof panel, butting panels together at the site, permitting some water to run down between them, and carrying it off below in troughs on top of the structural members or batten strips which bridge the joint. It was thought easier to maintain the integrity of such joints and troughs and simpler to make the joints in the field than in the more usual designs, and the mastics or caulking used under the panels would be shielded from the worst effects of the weather. On the other hand, many new and difficult problems of freezing and clogging had to be faced before the idea could be widely used.

2. Frame Assembly

This type of roof construction was almost invariably found in connection with pitched roofs where extensive use was to be made of the attic space beneath, and where the desired continuous surface of roofing applied over framing members was not so easily panelized in the factory as were other components. Furthermore, shortages of the larger pieces of dimension lumber and planning and construction advantages had led to an increasing interest in truss construction systems, with some prefabricators seeking additional benefits through the use of timber connectors. These specialized members tended to become the subject of quantity production themselves, and accordingly interest was turned away from the development of roof panels as such.

The possible advantages of the truss over the normal ceiling joist and rafter construction, in addition to permitting factory fabrication instead of difficult site work, lie in the use of shorter lengths of lumber, in the use of smaller sections of lumber if the truss spacing is the same as that of rafters or wider spacing if the sections are the same, in the resulting clear span from wall to wall without interior bearing partitions, and in the design freedom resulting from this clear span. Most truss systems break up the attic space, and so they tend to be employed in connection with designs which make no use of this space.

Production advantages of the truss lie in the fact that it can be jig-assembled by unskilled labor, that it undergoes little change of shape after fabrication, that it is not particularly bulky to ship or handle, and that it serves automatically to line up exterior walls and level ceiling surface.[42]

In this connection it is interesting to note that several steel fabricating concerns and at least one aluminum fabricating concern were offering lines of roof trusses to the general housebuilding market.

Few of the roofs in this category are insulated to any great extent so that, in order to prevent condensation from occurring in the attic space and to avoid overheating that space in hot weather, it is customary to ventilate the roof, either through louvered openings in the gable-end walls or through eave vents, or both, and to put a vapor barrier or insulation layer, or both, next to the ceiling. The roof structure thus becomes essentially an umbrella over the rest of the house. This is particularly true in the case of some of the metal roof systems, in which a much more serious condensation problem must be met by employing large quantities of moving air, and to which, because of their rib-like framework and thin protective skins, the umbrella analogy is much more clearly applicable.

In the Lustron house, for example, steel "hat sections" were welded together to make up trusses which, spaced 4′ o.c., supported vitreous enameled steel pans shaped to give the general appearance of tiles and interlocked in much the same way at the joints. Beneath this umbrella the air was quite free to move about, while a thick blanket of insulation protected the heating plenum chamber beneath.

The Steelcraft Manufacturing Company offered a house in which the steel angle trusses were spaced 8′ o.c., supporting a latticework of steel angle rafters 2′ o.c. and hat-section steel purlins 10″ o.c. Over this framing were laid aluminum sheets, to the underside of which was cemented 43 lb. felt. The edges of these sheets turned up to form vertical standing joints. Louvered openings at gable ends were used for ventilation.

These metal roofs were the exception, of course, rather than the general rule. A summary of the details used by the 52 companies using frame assembly construction in their roofs is given in Chart L.

[42] For a discussion of the use of roof trusses, see *HHFA Technical Bulletin*, no. 8 (January 1949), pp. 61–6.

Chart **L**

Frame Assembly Roof

52 Companies

Frame members	46	wood
	7	steel
	1	aluminum
	34	2″ × 6″
	7	2″ × 4″
	26	16″ o.c.
	15	24″ o.c.
	42	nailed
	7	screwed or bolted
	2	welded
	37	field
	14	shop
	46	part of ceiling construction? no
	4	yes
	23	top chord of truss? yes
	25	no
Structural cladding	24	wood
	21	plywood
	45	nailed
	3	screwed or bolted
	48	field
	3	shop
Roofing surface	14	asphalt shingles
	11	optional
	8	wood shingles
	51	field
	1	shop

21 *Southern California Homes house*

1 *showing living room interior*

2 *showing garden wall and storage unit*

22 *Reliance house*

23 *Section of AIROH house being unloaded from trailer*

24 *Pierce Foundation—Cemesto House*

25 *Production Line Structures—prototype house under construction*

26 *Wingfoot house, showing bedroom sections extended*

27 *Acorn house*

1 *folded unit in place, showing supporting beams in place*

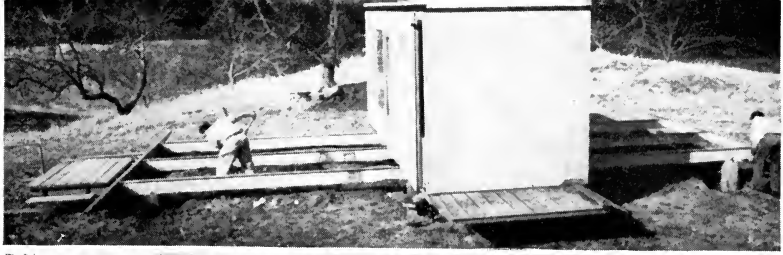
2 *unfolding floor and end wall*

3 *unfolding side walls*

4 *unfolding roof*

5 *completed house*

1



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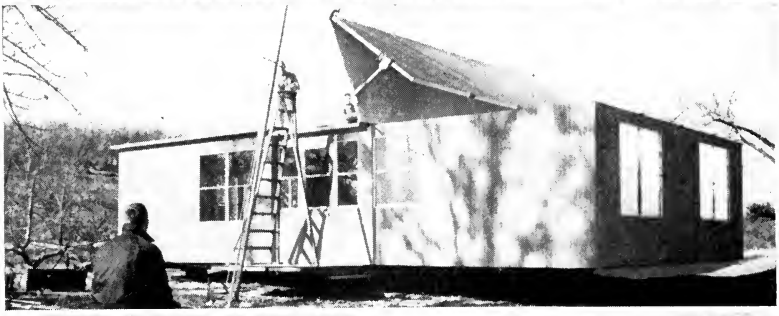

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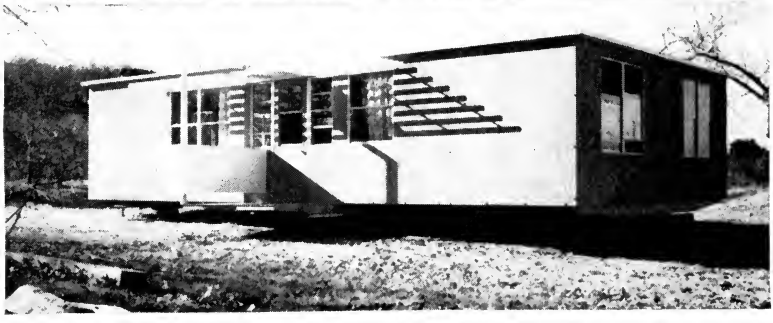
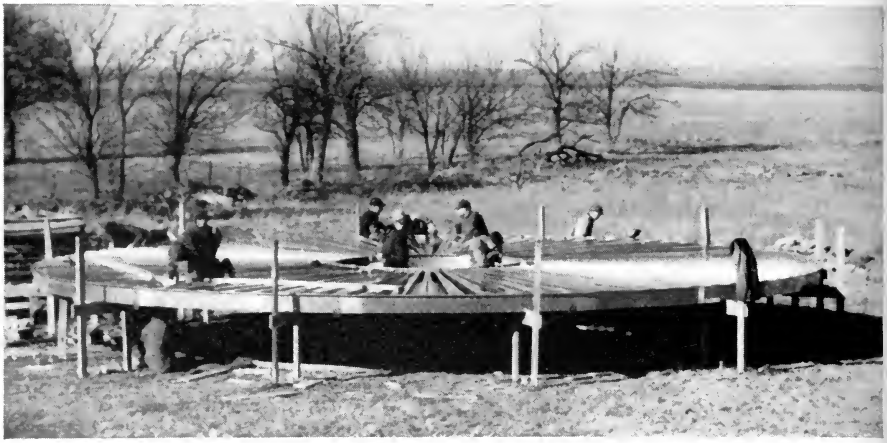




1

2

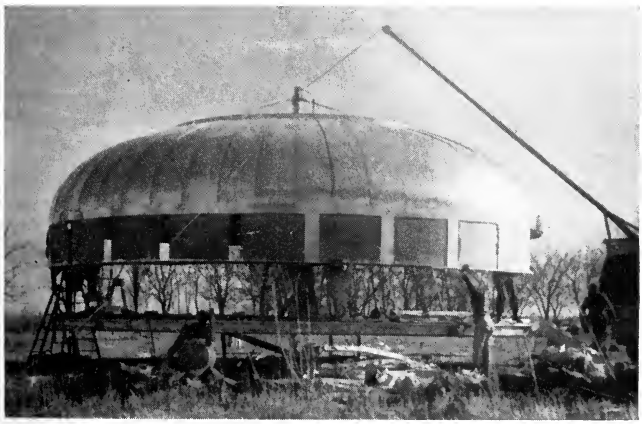
28 *The Fuller house under construction*

1 *floor structure laid*

2 *mast erected and roof structure assembled*

3 *roof raised and walls suspended*

4 *ventilator hoisted on to finished structure*



3

4

29 *Kaiser Community Homes house*

30 *Green's "solar house"*

3. Frame Panels

The same general considerations apply to a frame panel system as do to a frame assembly system, and again it will be noted that the large majority of prefabricators in this classification used wood and made it up in a relatively conventional manner, applying the roofing as a continuous surface at the site. In fact, since trusses were usually fabricated as units and rarely combined in panels, frame panel roof construction was on the whole even more conventional than frame assembly.

There were a few prefabricators, however, who sent out panels which were entire roofs, or large sections of roofs. These were, naturally enough, in the group which used mass-production methods in erection as well as in fabrication. One such was the Byrne Organization, which at Harundale made up in the project shop an entire pitched-roof frame of steel trusses to which wood sheathing and shingling were nailed and gable-end walls welded, also in the shop. The complete roof was then transported to the site, placed atop the house with a special lifting machine, and welded to the steel wall members.

The roof of the Hamill and Jones house was an unusual example of frame panel construction in wood. In the first place, this was one of the few hip-roof schemes. Also, the roof was made up of 4′ panels extending from eave to ridge or hip, with 2″ × 4″ rafters 24″ o.c. except at panel edges, where a 1″ × 4″ was used; V braces supported these rafters at center span. The most interesting feature was the fact that shingling was shop applied in such a way as to be woven together over the butt panel joints at the site. This was made possible by a master jig on which the whole roof assembly was put together in the shop, and then separated into panels for transportation to the site.

A summary of the construction details of the frame panel roofs used by 54 prefabricators is contained in Chart M.

4. Stressed Skin Panels

This type of construction was seldom used for a roof unless the underside of the panel was also to be used as a ceiling, for otherwise the extra strength and finish were not warranted. Thus it was principally a flat-roof construction. Since it is also the lightest sort of roof construction in most cases, special attention often had to be

Frame Panel Roof

54 Companies

Frame members	44	wood
	8	steel
	23	2″ × 6″
	10	2″ × 4″
	5	2″ × 3″
	2	2″ × 8″
	34	16″ o.c.
	9	24″ o.c.
	35	nailed
	8	glued and nailed
	5	screwed or bolted
	4	welded
	51	shop
	3	field
	46	part of ceiling construction? no
	8	yes
	39	top chord of truss? no
	15	yes
Panel size	22	eave to ridge × 4′
	3	eave to ridge × 8′
	3	width of roof × 4′
Joint	31	butt
	5	m and f
	4	interlock
Structural cladding	24	plywood
	16	wood
	34	nailed
	11	glued and nailed
	36	shop
	18	field

Roofing surface	19	asphalt shingles
	12	wood shingles
	9	optional
	4	painted metal
	4	built-up roof
	46	field
	8	shop

paid to negative wind-loadings which would tend to lift the panels free of the house.

The construction of several of these panels was described under stressed skin panel ceilings, p. 251. Further details regarding some of these may be given here. For the Southern California Homes house, the addition of an asphalt-base paint over the zinc chromate primer on the aluminum surface was considered advisable, and at the joints there was a metal cap over the standing panel edges and a cover strip on the underside of the panel joint to carry any seeping water down to gutters and downspouts. The Wingfoot roof panel was finished on the exterior with roll roofing mopped onto the complete roof panel surface in the factory.

In the proposed Fuller house, it was planned to rivet sheets of aluminum to W-shaped metal ribs which arched in umbrella fashion from a central supporting mast. Moisture was relatively free to enter the grooves of the W-shaped ribs, and in these grooves it was to be carried down to a gutter located inside the bottom edge of the roof. There has not been a great deal of experience with such inside drains to test their effectiveness in the face of freezing and clogging conditions, since for the most part they have been used in houses designed for warm and relatively dry climates.

Most of the companies used stressed skin panels in what might be called conventional manner, as will be seen from Chart N, which summarizes the construction details of the 14 companies constructing their roofs in this way.

5. Solid Panels

In the case of each of the six companies producing them, the solid panel roof systems were so designed that the underside could also serve as the ceiling of the space below. The weather surface

Chart **N**

Stressed Skin Panel Roof

14 Companies

Frame members or structural core	10	wood
	2	plastic-impregnated paper
	1	steel
	1	aluminum
	6	2″ × 6″
	2	2″ × 4″
	2	1″ × 4″
	7	16″ o.c.
	2	48″ o.c.
	1	12″ o.c.
	8	glued and nailed
	3	glued
	2	screwed or bolted
	12	shop
	2	field
	10	part of ceiling construction? yes
	4	no
	12	top chord of truss? no
	2	yes
Joint	5	butt
	3	special
	2	m and f
	2	interlock
	2	lap
Structural cladding	10	plywood
	3	aluminum
	1	steel
	9	glued and nailed
	3	hot press glue
	12	shop
	2	field

Roofing surface	6	built-up roll
	2	optional
	2	painted metal
	1	unpainted metal
	12	field
	2	shop
Insulation	6	batts
	2	metal foil
	1	felt

normally was the conventional built-up roofing of felt, asphalt, and mineral granules. A great deal of research was being devoted to the use of homogeneous materials such as improved concretes, wood waste composites, and rigid insulating compositions as self-supporting roof materials which might supply finish as well as surface and which offer at the same time the possibility of mass production of large, simple elements. This work had not led to commercial developments at the time of the survey.

6. Poured at Site

The few systems which fall under this heading have been described already under the same heading in the section on ceilings, since in every case poured monolithic ceilings also served as roofs. As a weather surface, the LeTourneau house had a coat of waterproofing applied to the standing shell. In the Neff Airform house, a layer of waterproofing compound was sprayed on the surface just beneath the final coat of gunite.

7. Gable-End Walls

In the many cases in which the attic was not designed for living space, the gable-end walls were single-surface, uninsulated sections. In all but a very few such cases, therefore, they were separate panels, rather than a vertical continuation of the end wall construction, which was likely to be quite different. It was also considered preferable to make a separate gable-end wall panel so that the lower wall panels

could be more thoroughly standardized. Of the companies making such panels 32 had wood louvers installed in them for ventilation, while another 15 used metal louvers.

IV. Miscellaneous Design Features

A. Plumbing

Many prefabricators took one step beyond most of the conventional builders in working out a standardized plumbing layout as an integral part of the house design. Seventy-eight companies were known to provide a standard and specific plumbing plan, detailing piping and connections, in their blueprints. In theory, prefabricators are in a good position to use the most advanced and economical methods commensurate with good engineering practice; actually, preference, prejudice, codes, the plumbing industry itself, and the unions have made it difficult to use such rational designs, or even to use standardized designs of relatively conventional nature over very wide marketing areas.

This problem was recognized by all concerned, and efforts were being made to solve it. Particular mention should be made here of tests made by the National Bureau of Standards, with the cooperation of the Housing and Home Finance Agency, of private groups, and of the plumbers themselves, to determine by scientific methods the answers to many long-standing plumbing controversies, and in the end to stimulate code simplifications which will have the support of all groups.[43]

As for the degree to which prefabricators are able to make use of rational plumbing designs, it can be pointed out that 49 companies had arranged to place their kitchen and bathroom fixtures back to back for simplified connections from a single "plumbing wall." The majority, however, seemed to feel that many a subcontractor refuses to pass along the savings made possible in this way, and since to some

[43] The Uniform Plumbing Code for Housing," *HHFA Technical Paper,* no. 6 (February 1948). Preliminary edition out of print, revised edition in preparation.

degree the requirement that these fixtures be back to back is a limitation of freedom in planning of kitchens and bathrooms, it could be disregarded.

Where the prefabricator actually put together part of his plumbing in the factory, however, he did not disregard the possibility of such savings in pipe and fittings. Of the 27 who assembled their own piping panels in the plant at the time of our survey, nearly all used back-to-back layouts. Six other companies, which themselves made no attempt to assemble the piping but only sent it along with the package already precut and threaded for local assembly, also sought back-to-back economies.

Many of the prefabricators were convinced that copper-tubing supply lines and soldered connections were more economical than the conventional iron, even though materials cost a bit more, because the labor costs were less. Some would even have liked to offer welded steel plumbing assemblies featuring pipe bent on tube turners, but feared conflict with existing code and inspection provisions. An interesting plumbing development was the plan of Southern California Homes to prefabricate its system completely in three sections, a copper-tubing supply system, an underground waste system, and a vent system.

The prefabrication of plumbing is one rational step which most prefabricators were anxious to take, for plumbing is a good example of an expensive item which can be completely standardized and which permits mass-production and mass-procurement economies at the same time as simpler handling and lower costs of erection. A typical prefabricator made the point clear with a question: "A complete set of plumbing materials and fixtures probably costs $100, but the installed cost of a bathroom is at least $500 or $600. Why?"

From the prefabrication of plumbing, the next step is the prefabrication or at least preassembly of the fixtures, too, and six companies attached fixtures to the piping in the plant. There is nothing new about this, or indeed about the fabrication of a specially designed combination of fixtures in the form of a single unit. Buckminster Fuller's bathroom design (see Figure 31) was tried out and seriously considered for mass production a dozen years ago, and at least 10 of the prefabricators who were visited had worked up designs for unit bathrooms or bathroom-kitchens.

A design for a bathroom unit which was in production at the time of the survey was that of Standard Fabrication, Inc., which had a guaranteed market contract for 25,000 units. The unit combined

bathtub, adjustable shower, toilet, lavatory, storage cabinet, and medicine cabinet with an integral low partition—all of stamped steel finished with porcelain enamel. The final dimensions were 7½′ long,

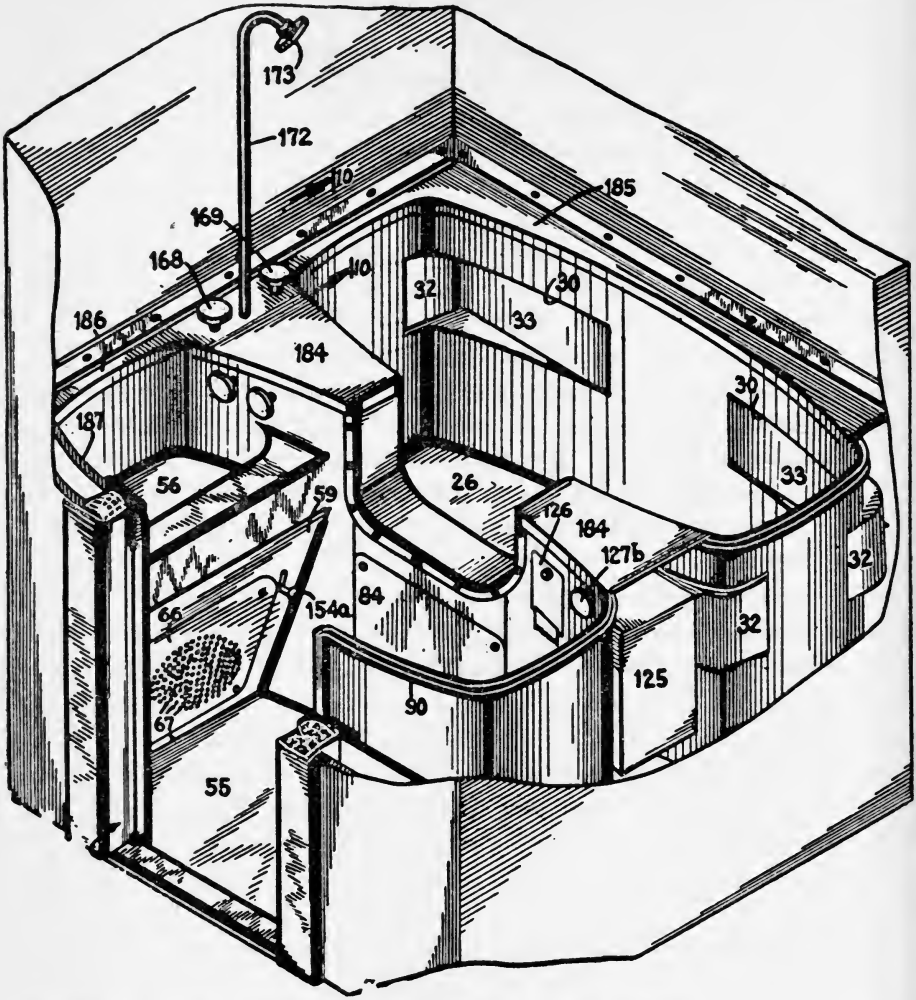


Figure 31. Patent Drawing for the Integrated Fuller Bathroom

4′ high, and 2½′ wide, making it possible to carry the unit through any door and install it in any room. The plumbing was built in, requiring only four site connections, with supply and waste lines and vent stacks.

B. Mechanical Cores

The discussion of plumbing leads naturally to the mechanical or utility core. The desire to combine all the plumbing, heating, and mechanical elements in the house in a single centralized and mass-produced core has long intrigued designers. Furthermore, it should be possible so to design such a core that it can be used in a variety of house plans, thereby combining in a single unit suited to production in large volume many of the troublesome and costly elements common to all houses within a certain range of sizes and types. Since several prefabricators estimated that the plumbing, heating, and electrical subcontracts alone commonly run as high as 25% of the total cost of the house, and in frequent cases even higher, this concept was widely studied.

A mechanical core so conceived might logically become a starting point for the rational architectural planning of the whole house, but few of the prefabricators felt they could afford to wait until the ideal core was in production, or to make major alterations in their designs to fit the cores already on the market. Still, such cores as there were offered the advantage of very great compactness, and they were in the main well suited to incorporation into prefabricated houses. Several of the prefabricators tried them out. Lustron used a similar approach in the design and production of its own plumbing wall and bathroom fixtures, and at least five others were working on their own mechanical cores, including Fuller. The cores available on the market, however, were not produced by prefabricators.

The best known of these was Borg-Warner Corporation's Ingersoll Utility Unit (see Figure 32). This was a standard unit consisting of a mechanical core plus kitchen and bathroom equipment, and containing the major installations, equipment, and controls for heat, electricity, water, and gas. In the mechanical core was a forced warm-air furnace with blower, air filter, and thermostatic controls; an automatic water heater, either electric or gas; a prefabricated sewer stack and vents; a prefabricated copper water-piping assembly and gas lines; a chimney flue base with drafts or dampers, depending on fuel; complete wiring and multibreaker for all components, plus thinwall conduit; and a cold-air return system—all mounted within a welded steel channel frame 30″ wide, 94″ long, and 77″ high, with attached wood stripping to which to fasten finishing materials. The kitchen equipment included a 7 cu. ft. refrigerator, a single-bowl porcelain enamel sink with supply and waste connections to the core,

a four-burner range, and various cabinets and lights. The bathroom equipment included tub, lavatory, and water closet, together with connections, standard accessories, and medicine cabinet.

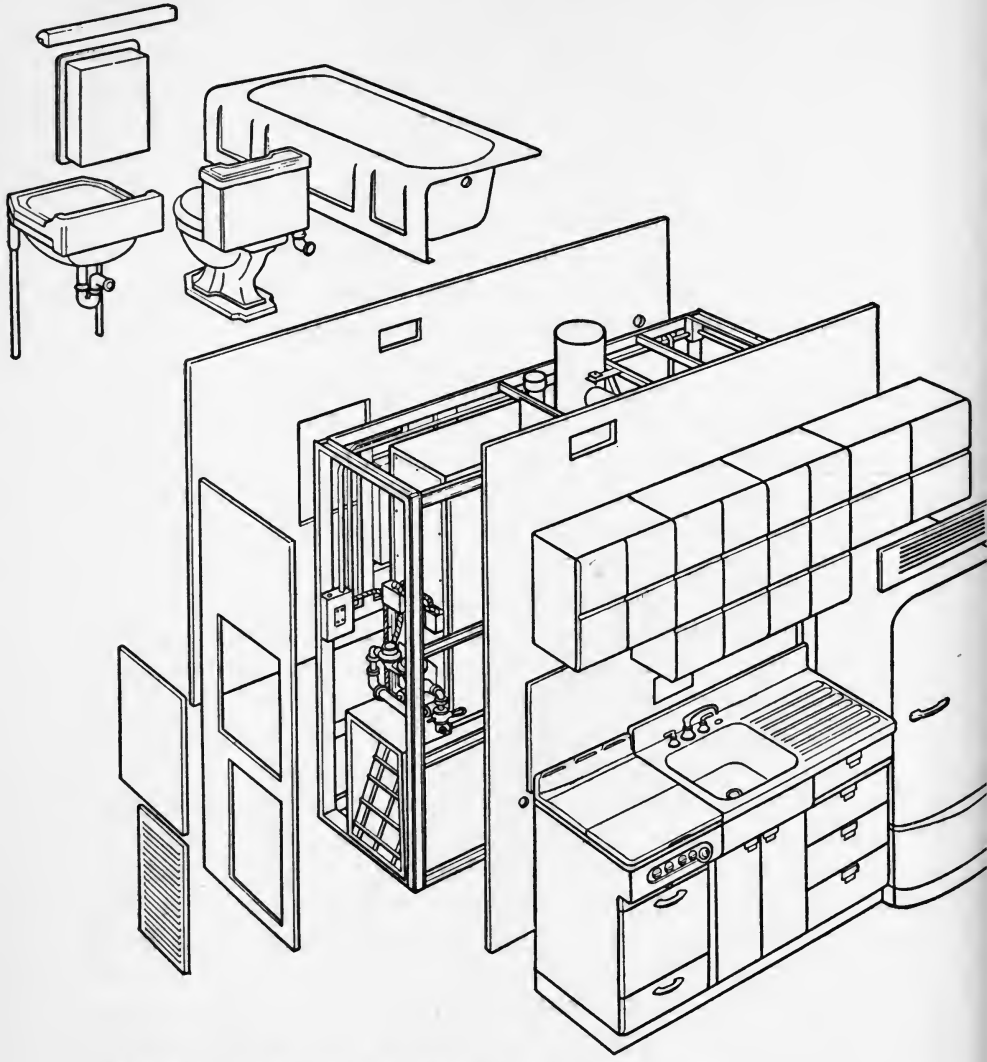


Figure 32. Exploded Drawing of Ingersoll Utility Unit

The builder or contractor installing the unit had to supply plenum chamber, ducts, registers, and chimney piping for the furnace; lead-in lines for sewer, water, gas, oil, and electricity to the core; soffits to the ceiling above the core; access and clean-out panels; and plaster or wallboard sheathing and all finishing materials.

A "deluxe" model added laundry equipment, a few refinements, and some rather larger items than supplied in the standard model. Borg-Warner manufactured many of the elements in addition to assembling the core and planned eventually to manufacture all the units contained in the core. At the time of the survey, the unit was generally somewhat more expensive than comparable equipment assembled locally, but it was sometimes able to compete because of convenience of installation or because essential elements might not always be locally available. A few prefabricators were using this core, but most were proceeding with local assembly, with an eye on the relative cost figures (thus making it difficult for Borg-Warner to realize the economies possible through mass production [44]).

A different approach was used by Timber Structures, Inc., the producer of Mobilcore. This was actually a factory-built kitchen, bathroom, and dinette or utility room, complete and ready for attachment to a new or old house, rather than just a core and equipment package for insertion between kitchen and bathroom. In one model, this prefabricated section was 24′ long, 8′ wide, and 9′ high, with walls, floors, and ceiling of conventional wood frame design and floors factory finished with linoleum. The usual fixtures, attachments, and storage elements came in the standard model, with heater, hot-water heater, laundry tray, storage cabinet, and exterior door in the optional utility room, and stove, refrigerator, and mechanical washer also optional features. When hooked up with utilities, this unit was ready to use.

An interesting sidelight of this development was the design for a rather unusual house worked out by the company as the result of measures taken to protect the unit during installation. In this design the basic mechanical unit served as the load-bearing structure on which were placed cantilevered trusses to support not only the roof but also a set of non-load-bearing exterior curtain walls. This supports the theory, often put forward, that ultimately the rational prefabricated house will be an outgrowth of the mass-produced mechanical core, rather than the reverse.

Several companies evinced interest in prefabricating complete kitchen units. The Puraire kitchen, for example, was designed for use in small homes and in converting large houses to housekeeping apartments. It came complete with sink, stove, refrigerator, and storage facilities, and it has been used as a convenient manner of supplying the full kitchen equipment in at least one development of prefabri-

[44] Borg-Warner suspended production of the Ingersoll Utility Unit on June 30, 1949. In the words of *Progressive Architecture,* XXX (June 1949), 1, it "failed to meet the present economy demand for minimum units."

cated houses—that for married veterans at Massachusetts Institute of Technology. The use of or manufacture of such partial units, and of bathroom units, has long been considered by the prefabricators but almost none were actually used by them at the time of the survey, for reasons of cost, design complication, and marketing difficulty. Presumably the other problems would be more willingly faced were the costs to come down.

C. Heating

Heating is an important element of any scheme for housing in the greater part of the United States, and the prefabricators were well aware of this fact. They followed with interest the recent developments of the heating industry, and the new ideas on which extensive research was being done. In order to stay within the price range which seemed to them best suited to the concept of prefabrication, most of them hesitated to try anything requiring large initial capital investment. At the same time, in order to stay well within what they considered the range of general public acceptance, most of them also hesitated to try anything radically new.

Of the companies visited, 70 had decided upon a specific and standard heating layout for their houses, and, of these, 50 commonly supplied the heating unit, while nine more offered the unit at the purchaser's option. At least 50 of the companies regularly supplied prefabricated stacks or flues of metal or asbestos cement, and three more supplied them at the option of the purchaser. Only a few of the prefabricators attempted to take advantage of their quantity production to procure a heating unit specially tailored in size and character to their house; the Byrne Organization designed a boiler for its radiant-heated floor slab, and Lustron an overhead heater and plenum chamber for its radiant heating ceiling panels.

It will be noted that, with a very few exceptions, the prefabricators have avoided the use of hot-water or steam piping and radiator-type heating systems, and of any system requiring coal as a fuel. This is clearly the result of a balance of convenience and cheapness of installation with convenience of operation. Certainly the most popular heating systems from the point of view of the prefabricators were the various warm-air systems. In areas where natural gas was available at low cost, gas-fired warm-air systems were the rule.

1. Gravity Warm-Air Heating

Gravity warm-air heating systems were specified by 14 companies, and, of these, 13 companies regularly furnished the furnace as part of their package. Most popular seemed to be the floor furnace, which takes up a minimum amount of usable living space and, with proper design, gives reasonably satisfactory performance for a small house. It requires no ductwork to distribute the warm air and is for that reason probably the least expensive heater in terms of initial cost.

In some cases, two warm-air heaters were installed, one as a stand-by to go into action only in conditions of extreme cold. In at least three cases, a vertical stack was added over the heater to speed up air movement in the manner of a chimney and to get more even heat distribution. In the Kaiser Community Homes house, such a stack had louvered openings near the ceiling, which, combined with the cool-air intake near the floor, provided a better circulation of air than is usually possible in basementless gravity units.

2. Forced Warm-Air Heating

Forced warm-air heating was specified by 22 companies, although in several cases only as an optional feature. Only a few found it advisable to furnish such units for use with conventional duct systems. At least 13 companies supplied prefabricated ducts, plenums, and even risers with their packages, and, when required to do so for houses with basements, they provided the necessary risers, ducts, and grilles in the walls. In basementless houses, some of the companies supplied prefabricated plenum chambers of metal or asbestos cement, usually concealed above a dropped ceiling in the central hall, to distribute the heat from the warm-air discharge to various sections of the house.

Interesting technical developments coming on the market at the time of the survey but not yet used by the prefabricators included very compact furnaces designed to make use of high-powered combustion principles worked out during the war for aircraft heating and to distribute the heat through flexible hosing instead of ducts; these were based on concepts of few moving parts and high operating efficiency.

3. Radiant Panel Heating

Widely discussed in general, radiant panel heating systems have been of particular interest to the prefabricators. Since such systems require careful engineering and close adjustment to the characteristics of the house in which they are to be installed, and since the cost of installation in some cases shows promise of coming down to the small-house range only through the application of industrial techniques and repetitive production, their use would seem to offer a special advantage to those who manufacture a limited range of models in large-quantity production and who can, therefore, afford to spend money for a careful integration of the house and heating design and for the necessary tooling up. Houses which offered radiant heating without excessive cost, whether in the floor, walls, or ceiling, and whether by means of warm air, hot water, or electric resistance elements, appeared to have gained, because of general public interest and favor, a sales advantage over those which offered conventional heating.

Radiant floors were the most common of the radiant systems installed or specified by prefabricators at the time of our survey. At least nine of the companies were using them or were planning to do so, six with concrete floor slabs in basementless houses and three with wood floor systems. Of the concrete slab installations, the majority circulated hot water in copper tubing. The Harundale project of the Byrne Organization had a 40-gallon, specially designed hot-water boiler which also supplied the hot-water needs of the house, and a pump to circulate the hot water through copper tubing which was spaced at 1′ intervals in most of the slab and somewhat closer in the kitchen and bathroom. In this fairly typical installation, slab surface temperature was designed for 85° F., and it was hoped to keep heat loss into the ground as low as 10%. The economies of combining domestic hot water and heating, and of obtaining an efficient design of floor slab for a cold climate, together with potential fuel economies, had to be balanced against somewhat higher installation cost and several recognized design problems. These included the problems caused by time lag in supplying or in reducing heat because of the large mass of the concrete slab, the need to provide against accidental blocking or progressive obstruction of the tubing, the complications caused by rugs and other floor coverings, the interferences resulting from other plumbing and mechanical installations, and the measures which must be taken to protect against freezing the water and bursting the tubing during unheated periods in extremely cold weather.

Three companies had erected experimental models of systems which made a radiant panel of a wood floor system by using the space between the floor and the ground slab of a basementless house as a plenum chamber heated by forced warm air. In an experimental house built by the Field Detroit Co., warm air was forced into the plenum at the center and returned to the house through registers located beneath the windows. In the Green's Ready-Built house, warm air was first circulated through the house, then returned through registers to the underfloor plenum, and eventually carried back to the furnace. (This system was not approved by the FHA.) The Solar Homes Co. used warm air circulated in the space between the floor joists, which was covered and insulated at the bottom to produce a sort of duct.

Three other companies were experimenting with forced warm air in various hollow slab or tile systems.

Radiant walls were not in production among the prefabricators visited, although a few were experimenting with them. This was in part the result of the difficulty of designing a heating system for uniform performance at different distances from the walls and for surfaces which are complicated by numerous openings and many insulation problems.

Radiant ceilings were scheduled for regular production in only two houses. One of these was the Lustron house, the heating system of which has already been described on p. 247. The other was the Modern Standardized Buildings Co. house, in which warm air was heated as it rose through a series of finned hot-water coils and was then conducted into a plenum at the ceiling, made up of a sheet of ⅛″ asbestos cement which was suspended 2″ below a sheet of aluminum foil backed by 2″ of blanket insulation. A ¾″ open space between the edge of this plenum and the wall permitted the warm air to circulate down into the house area and then to return to the heater.

These two systems reflect the design interest in ceiling installations which many consider the most satisfactory from the point of view of the physiological needs of the body. Unhampered by the large mass of the floor slab and by the problem of floor coverings, the ceiling panel can be highly efficient in its action and can greatly assist the development of open and flexible planning; nevertheless, it creates the new difficulties of installing a somewhat complex structure at ceiling height and of insulating it against heat loss upward into the attic or roof areas. Other new techniques such as the use of electric resistance panels, either of a special rubber material such as

the United States Rubber Company's Uskon, or of conductive aluminum alloy fused into tempered glass, were being carefully studied where costs of electric power were sufficiently low (1½¢ per kilowatt hour or less), because of the possibilities offered for extremely low installation costs and efficient use of heat.

4. Solar Heating

Very few companies at the time of our survey were attempting any considerable use of solar radiation to heat their houses, and those few were interested only in the use of large so-called "solar" windows, facing directly south and so shielded that the sun can penetrate the window and warm the interior space in winter but cannot penetrate in summer. This idea has captured the imagination of many architects and, to some extent, the public. The technical, psychological, and esthetic arguments and pronouncements pro and con are well known and need not be rehearsed here.

Green's Ready-Built solar house was designed expressly to utilize solar heat. Most of the living spaces had large windows to the south, so that the house tended to be long and narrow, running from east to west. The design of the windows, with fixed glass and openable, louvered, and screened ventilation areas above and below, has been discussed on p. 232. There was also added to the exterior of the house a series of louvered screens projecting from the wall between window areas, which served to protect the windows against late afternoon sunshine without interfering with the flow of air along the southern front of the house. This house, frankly designed for the middle-income group, received a good deal of architectural acclaim, but it was never put into mass production, at first because of limitations imposed by the Veterans' Emergency Housing Program and later because of the failure of the company.

No prefabricator was known to have made any attempt to put into production a heating system designed to trap the solar radiation impinging on the house, to use some of it for immediate heating, and to store the rest for later use when solar radiation is not available. Research in this field is followed with interest in many quarters, but is not yet at a stage where its advantages or disadvantages are clearly known.

D. Electrical Wiring and Fixtures

The intended position of electrical outlets was specified by 69 companies, and 49 prefabricated their wiring to some degree. Of these latter, 11 simply precut it, nine factory-installed dummy lines in the conduit to help the electricians pull through the wires in the field, and 27 actually preinstalled the wiring, usually in wall panels. Most of these companies used BX or Romex cable rather than rigid metal conduit, and in some communities they encountered code difficulties on that score.

The average prefabricated wiring system had outlets in the wall panels, with the connecting cable stapled or clipped by brackets to the structural members or run through conduit cast in the walls. The connecting wire usually projected through the top or bottom edge of the panel, with the balance of the wiring placed inside during shipment, ready to be pulled into position in the attic or crawl space at the site, and attached to major circuits and to service leads from outside.

A few companies had devised systems for prefabricating the major circuit wiring (for example, by stapling connecting wires to a board running the length of the attic space) so that all that was necessary at the site, after connecting house circuits, was to connect this "harness" to the service leads. In such a case, the meter and a master circuit breaker or fuse box, or both, were also wired and installed on a panel in advance.

Most prefabricators felt that the savings possible from prefabricating their electric wiring, if their construction permitted it at all, were not great enough to justify the probable difficulties with code and labor which would result. Many companies which had no wall panels adapted to prefabricated wiring of this sort used a channel behind the baseboard or a molding attached to the baseboard to carry the wiring inside it. In concrete systems there frequently were metal or cardboard conduits cast in place. In all systems there seemed to be a general desire to keep the outlets at or near baseboard level, and to run cable for ceiling or wall fixtures or switches up behind batten strips at joints, or inside door casings. For example, Southern California Homes used a 2″ box section at the base of its panel, among other reasons, for wiring, and ran wiring for three wall and overhead fixtures and a few switches inside the channels which served as the edges of the panels, the wiring being placed in these channels before they were bonded to the skin surfaces of the panels.

Few companies had given special attention to the design of lighting fixtures or to a general lighting plan, although in this field lies another possible advantage of the prefabricator over the conventional builder. Such companies as were concerned about fixtures had for the most part concentrated on getting maximum procurement advantages from mass orders without, so far as was seen, attempting to engineer and produce a house in which lighting might reach a standard of high performance.

E. Acoustical Treatment

A very few companies had given serious attention to the acoustical properties of their houses, and these were the companies offering houses of unconventional design or construction which might give rise to particular problems. Even they relied primarily on the furnishings for the deadening of sound. Only one house (Green's Ready-Built) is known to have made use of acoustical tile for its standard ceiling surface.

No attempt was made in this survey to make scientific acoustic measurements or tests, but there were many houses in which reverberation was noted, and several more in which the partitions and doors could not have been much above the level of acoustical transparency. The problem would have been much more prominent had the companies visited not limited their interests primarily to the prefabrication of small detached houses. No doubt, more attention will be devoted in the future than at present to the noise problem, even in such detached houses, for in lightweight construction noise may cause a great deal of unpleasantness and yet its solution is known to be neither complex nor unduly expensive.

F. Built-in Furniture

Many of the prefabricators were aware of the advantages they could offer over conventional builders by building in elements of furniture and storage at the plant, particularly when it was possible in this way to make use of scraps of material which would otherwise be wasted and, by the use of their regular equipment, to produce articles which could hardly be duplicated at the site for comparable costs. Thus

one company (Red-E-Bilt Homes) offered a series of inexpensive built-in features (a mahogany-veneered ceiling in the entry, a kitchen ceiling vent, ironing board, and spice cabinet, and, in the garage, a workbench) which, in its opinion, added considerably to the sales appeal of the house.

At least 73 companies regularly supplied kitchen sink cabinets as a part of the package, and 66 supplied other kitchen cabinets, but six companies supplied kitchen cabinets only as an optional feature. All their cabinets were manufactured by 31 companies, in each case out of wood. Several said they did so only because of cabinet shortages, but many others found that they could in this way make use of facilities which were well suited to this kind of work.

Other built-in features included dining tables (seven companies), bureaus, or dressing tables and drawer space (eight companies), and storage or closet walls (17 companies). All these features appeared to be growing in popularity, particularly the use of storage or closet walls in place of partitions, with the storage and closet areas properly subdivided and drawers provided where necessary. Such storage-walls were supplied primarily in construction systems permitting the use of non-load-bearing partitions.

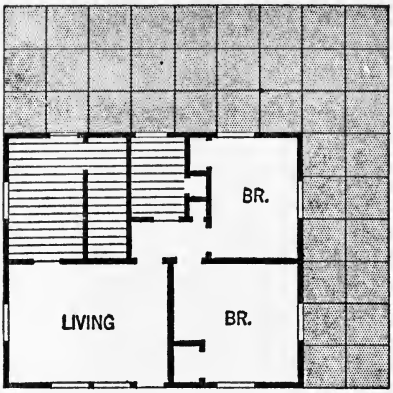
Building in furniture to a greater degree than this was limited to a few companies offering minimum plans in which high efficiency was possible only through special design of the furnishings as well as of the structure itself, and to a few other companies offering houses for special purposes; for example, in the construction areas of the Tennessee Valley Authority, where it was found practical and economical to build completely finished houses, to transport them to the site in sections, and to move them away to a new site when the occasion demanded.

Though none of the prefabricators had actually made designs, a few were considering plans in which certain standard elements such as beds might be built in, which would afford the extra saving of not having to finish the floor under the bed as well as the possibility of using the space under the bed for storage drawers.

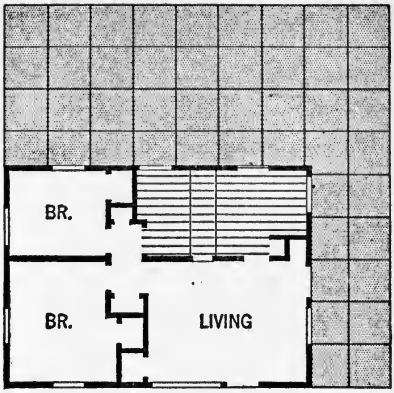
G. Space Arrangement

Without a detailed consideration of floor plans and other architectural elements, the quality of architectural space planning cannot be properly discussed. On the other hand, space planning in small

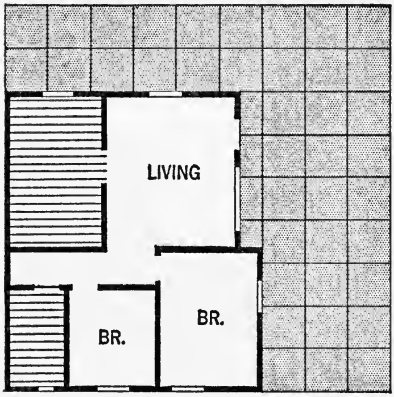
Figure 33. Plans of Selected Prefabricated Houses. These plans are presented on a uniform 4′ grid so that the allocation of space and the overall areas may readily be compared. Kitchen, bath, and utility area have been shaded. A number of unconventional houses have been included for contrast, as have the plans of three-bedroom models.



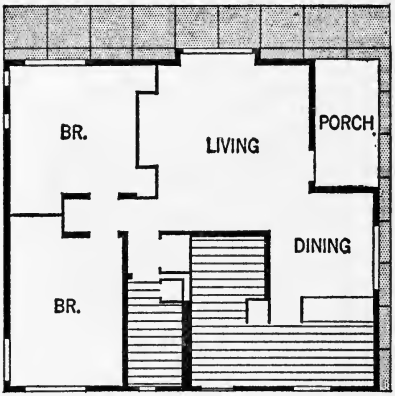
Gunnison Homes - Basic



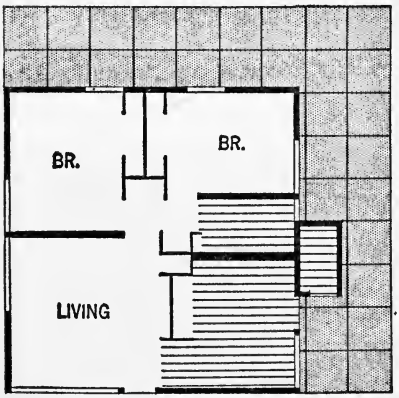
Shelter Industries



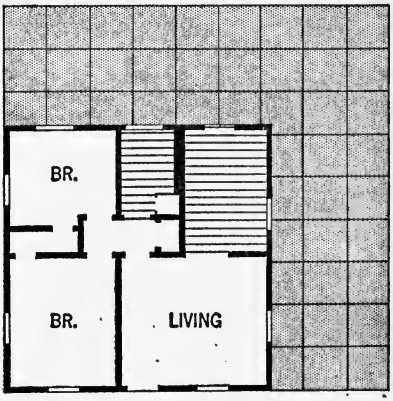
Ibec Corp.



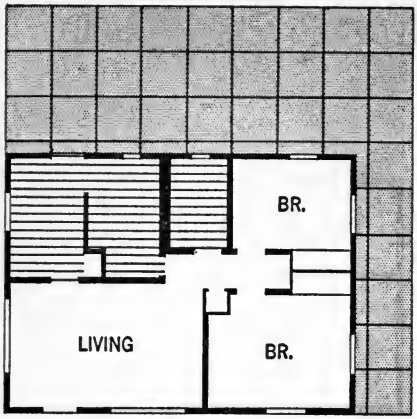
Lustron Corp. - Standard



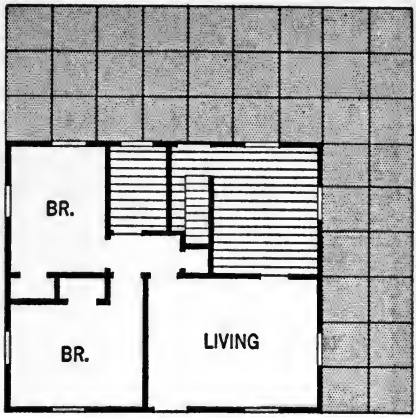
Southern Calif. Homes



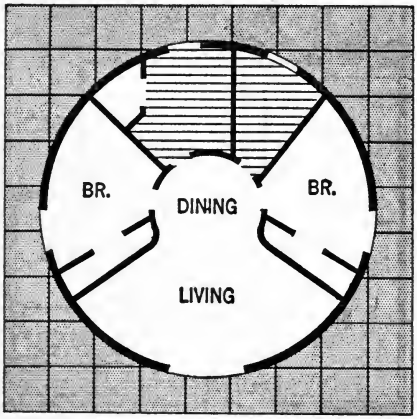
Crawford Corp. - Basic



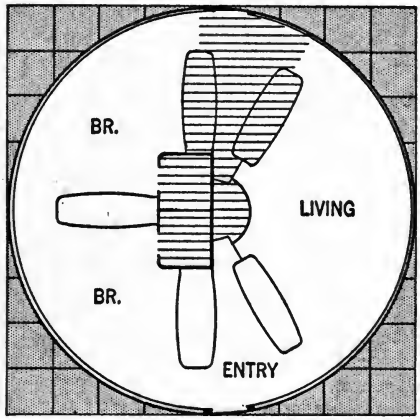
Lustron Corp. - Economy



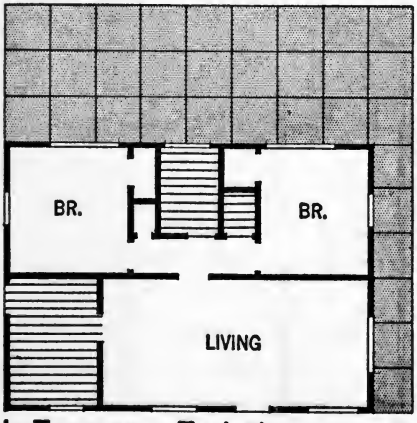
American Houses - Basic



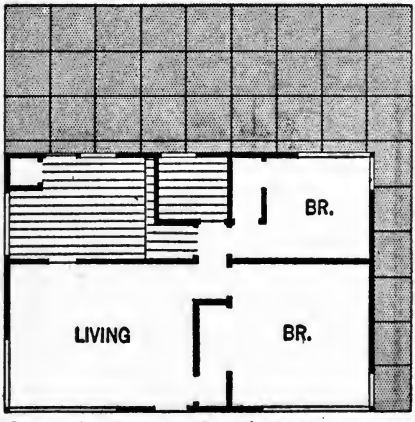
Airform House - Typical



Fuller House

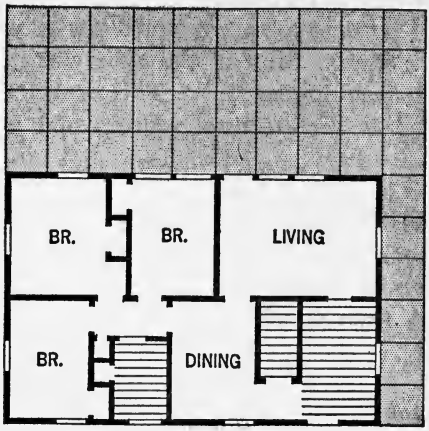


LeTourneau - Typical

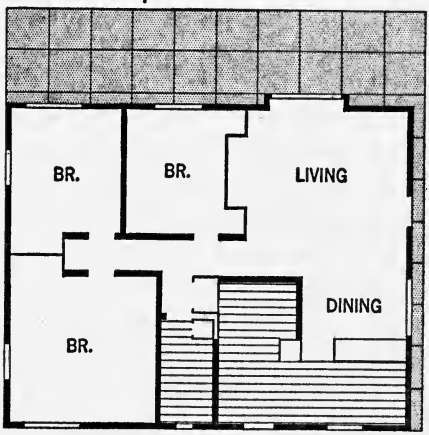


Green's Ready-Built Homes - Veterans

Gunnison Homes



Lustron Corp.



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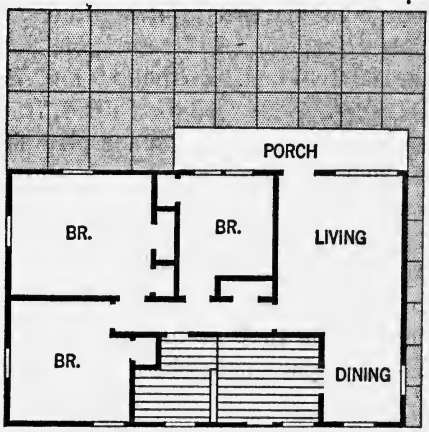


houses is largely dictated by the needs of family living, and while there is no single rational approach to the small house plan, the combined pressure of needs and costs greatly limits the choices open to the designer. Most of the plans were in many respects similar, as a result (see Figure 33). This aspect of the subject has been well treated in architectural sources and needs no further development here.

It is important, however, to give some idea of the standards of space provided by the prefabricators at the time of the survey. The following summary averages the room sizes of the most popular plans and models of typical companies. The figures give the number of companies from which the average was compiled as well as the average itself:

Number of Companies	*Room*	*Average Size (sq. ft.)*
48	Living	199
12	Living-dining	220
34	Kitchen	92
25	Kitchen-dining	116
20	Dining area [1]	76
62	Master bedroom	136
59	2nd bedroom	108
12	3rd bedroom [2]	113
39	Closet area	34
16	Other storage area	58
22	Utility	52
13	Covered porch	63

[1] There were very few companies with separate dining rooms. These were usually ells.
[2] More two-bedroom than three-bedroom houses were minimum in space planning.

Combining the figures for average room sizes, we find that the three different combinations of living-dining-kitchen areas result in average houses (allowing 10% wastage in floor planning) of the following floor areas: two-bedroom house, 770, 773, or 830 sq. ft.; and three-bedroom house, 894, 898, or 955 sq. ft.

Trends in the matter of space planning included an increasing use of truss roofs, with the resulting freedom of interior arrangement, and an increasing interest in the three-bedroom house. The Kaiser Community Homes project in Los Angeles built only three-bedroom houses, and many of the more conventional wood prefabricators were turning to story-and-a-half houses in order to get extra bedroom space, although at the time of the survey many of them were leaving this second-story space unfinished for later finishing by the purchaser.

The prefabricated house, on the average, was not generally distinguishable from the conventional product in respect to the space allocated to closets, utility room, bathroom, or kitchen, although there were instances in which prefabricated houses offered increased efficiency in respect to all of these. Of the two, there was more likelihood that one would find space wasted or inefficiently used in the conventional house. In a carefully prepared ratio of usable or efficient space to price, the average prefabricator would probably do better than the average conventional builder.

The previous summary indicates that at least 13 companies offered covered porches. Despite many architectural and marketing advantages favoring such a combined entranceway, play, recreation, and storage space, it was not generally offered as a standard part of the prefabrication package.

There had been little experience with the practical effectiveness of the very different space relationships offered in houses of specialized construction and form, such as the Fuller or Neff house, since almost no houses of this type had reached the common market in this country. Published descriptions of these houses met with a strong interest and, in certain segments of the public, with a decided approval. Further than this, the many attractive adaptations of the "Quonset" hut structures as houses in the last few years have added to the evidence that space planning and relationships quite different from those believed to be required by the general public may be found to be entirely acceptable.

H. Product Variety

1. Quality Standards

More than one quality standard in their houses were offered by 15 companies, with the difference lying primarily in the materials used, in the size and spacing of members, or in the degree of finish and number of fixtures added. A common practice was for a company to offer one house for sale on the general market to individual homeowners, and substantially the same house, but of different quality standard, for sale to industrial concerns or developers buying groups of houses for rental or sale, typically in new communities. Or a com-

pany might offer one version of a house which would be eligible for FHA insurance or pass certain building codes, and another version which would not.

Typifying the latter production plan was U. S. Homes, Inc., which offered a "Suburban Home" and a "Village Home." Essentially the same in general appearance and floor plan, the "Suburban" had a finish floor of oak and inlaid linoleum, while the "Village" had southern pine tongue and groove flooring and printed felt-base linoleum. The "Suburban" had bathtub, laundry tray, medicine cabinet, hot-water heater, and forced air heater with ducts supplied with the package, while the "Village" had none of these. The "Suburban" also had linoleum covering over its sink cabinet.

2. Basic Design Standards

Several basic design standards were offered by 13 of the companies, either to reach a wider market or to experiment with very different designs produced at the same time and under the same conditions. Thus, Texas Housing Co. produced a "Town and Country" house of 768 sq. ft. floor area with more or less conventional wood frame design, and also a 16′ × 16′ "Homette" developed from army hutment designs and having a pyramidal roof of the same 2″ plywood panel construction as the walls. The former was acceptable for FHA insurance and would pass most building codes, while the latter was designed for emergency situations, for public or university temporary minimum housing, or for owner-built houses for temporary use or in minimum housing areas.

3. Architectural Styles

The houses of any one company were usually of a single architectural style or character, but 17 companies offered two styles, four offered three, and five offered more than three, most of the last being those companies which were prepared to make up nearly any style desired on a job-lot basis. Often those offering more than one style were offering a "modern" house with flat roof to see how well it would sell in the prevailing market, and generally the companies do-

ing this reported that their "modern" models were not doing very well. This may represent a market prejudice, but it was probably also a reflection of the quality of the design which some of the prefabricators termed "modern."

There has been an earlier discussion of the general matter of architectural style on pp. 194–6, but it may be added that most of the prefabricated houses on the market at the time of the survey were supposedly reminiscent of, and often termed, Cape Cod cottages. Since many of the prefabricators preferred not to have to supply such details as shutters (where these were supplied they often were long, hanging well below the window sill to give an appearance of larger windows), colonial entrances, and the like, there was also a tendency to call the resulting unornamented, pitched-roof house by the style name of "American cottage." There was also a tendency towards a new name, and partly also towards a real style, called the "ranch house," theoretically all on one floor, with large windows and good cross ventilation, rambling in character, and incorporating several outdoor living areas, although in a small prefabricated house these aims were rarely accomplished in fact.

4. Achieving Variety

There appeared to be, at the time of the survey, a definite opinion on the part of many prefabricators (and probably of much of the general public as well) that some sort of variety would have to be offered in prefabricated houses, on the theory that people insist on individuality in their homes, particularly if large projects are to be made up of the same units. However, the architects of some of the companies were satisfied that variation in actual form and space arrangement could be very limited and still give the public what it wants; they tended to agree that the worst form of monotony is the monotony of slight variation. Some of the largest enterprises were offering a single model, without even the variation of left and right plans, presumably on the theory that mass production should start with maximum standardization and that the resulting product should be superior enough to that of its competitors to attract purchasers despite any emotional resistance they might feel at first to the idea of standardized houses. The subtleties and merits of the arguments pro and con need not be rehearsed here, but it does seem to be a fact

that the largest volumes, and in many ways the lowest costs, were being reached by those offering the least variety and relying on color and good site planning for the creation of distinction within a general pattern.

Many more prefabricators, however, sought to make nominal variety possible on easy terms by offering different types of entrance, of exterior finishing material, of window trim, of shutters, porches, garages, breezeways, and of colors, all amplified by right and left plans. Of these, a substantial number found it practical in effect to limit their prefabrication to a chassis of some sort and to finish the houses in the field with a wide variety of "treatments." They represented a sort of mid-position between those who believed that maximum economies could be achieved only by strict standardization of the complete house and those who believed that the public could best be served by a maximum standardization only of the panels and assembly parts, leaving it to the local man to put these elements together in any form he might wish. It has not been possible as yet to determine with any degree of assurance what the market will show with reference to these varying points of view.

5. Models

Assuming the same structural system and architectural style, many companies offered variety through different floor plans—sometimes different only in arrangement, but usually different also in size. At the time of the survey, 14 companies offered two plans, seven offered three plans, 12 offered four or five plans, 16 offered five to ten plans, five offered 11 to 25 plans, two more than 25 plans, and six any plan at all, depending upon the order. Further than that, at least 21 companies offered both right and left plans.

Several of the companies, after having offered a variety of models and having learned that certain ones sold badly, discontinued production of the less popular models. Thus, Kaiser Community Homes originally offered both two-bedroom and three-bedroom houses in the Los Angeles area, but at the time of the survey only the three-bedroom model was being produced. Harnischfeger, after having limited the number of models, was able to achieve further economies by producing the components of the remaining models in larger panel sizes.

6. Flexibility within the House

There is a common belief that one advantage of the prefabricated house is the ability to alter or add to it at pleasure. Actually only 22 companies emphasized the possibility of adding rooms or wings, supplied by them, at a later date. Few, if any, stressed the possibility of moving partitions about to meet changing family needs or developed designs pointing out various alternatives, even when truss roof construction would permit this. Although certain designs, particularly the modular panel systems with universal interlocking joints, had a basic demountability which might lend itself to rearrangement or addition over the years, particularly if this desire is taken into account in planning the layout and capacities of the mechanical system, there had been little actual experience with this sort of thing other than the experience with the demountable war housing. When the time came to move these houses, all of which were carefully designed to be demountable, most of them were simply sawed into sections and carried off without taking the trouble to follow the dismantling system. Nevertheless, many of the prefabricators offered schemes which were to some degree demountable and which offered possibilities of obtaining elasticity of plan through moving component elements, adding other elements, or taking elements away and replacing them with others. Important economies might be gained through planning for re-use value or resale and secondhand value. None of these possibilities had been tested in the market, however, and the tremendous site planning problems involved had hardly been considered.

Part II.

Chapter 8

PROCUREMENT

This chapter and the following one are devoted to two phases of the actual manufacturing process: procurement and production. The distinction between these two seems easy to make; procurement is the purchasing of the materials and finished goods which pass through the prefabricator's plant, and production is the actual business of performing work on material to produce a product. Yet the line is sometimes hard to draw; for instance, are those prefabricators who do no more than assemble a house package from fabricated components purchased from others engaging in procurement or production? This difficulty of distinction emphasizes the point that economies may accrue to the prefabricator as much because of the large scale of his operations, particularly in procurement, as because of his skill in factory production *per se.* It is important to understand the advantages, real or potential, which stem from each of these two phases of the manufacturing process.

Procurement advantages stem primarily from size. It is the fact that the prefabricator buys in carload lots, that he must spend large amounts of working capital for materials inventories, and that he is in a position to carry out himself the functions of handling, sorting, grading, and repackaging, which puts him in a position to buy direct from the manufacturer. Such advantages are, naturally, available to either a prefabricator or a large operative builder, and it is a fact that at the time of the survey the largest operative builder and the largest prefabricators were of roughly the same size, judged by their volume (1,000–3,000 houses per year).[1]

In the following pages are examined the prefabricator's procurement policies and the extent to which he was, in fact, able to lower his costs in three kinds of purchases: raw materials, finished items for which he acted as a jobber, and fabricated components.

I. Raw Materials

It is significant that most companies at the time of the survey thought that cost reductions were more likely to be realized through a change in the conventional materials distribution system than

[1] Levitt, 3,000 in 1947; American Houses, 1,600 in 1947; Kaiser Community Homes, 2,500 in 1947; National Homes, 2,500 in 1947.

through any other single factor in the whole realm of manufacturing. This was particularly true, of course, of those companies which counted on volume production rather than on unconventional construction or materials for their economies, and it seemed to be the case whether or not the firms had as yet actually realized such economies.

Certainly there would seem to be potentialities for cost reduction in the distribution of materials. The following table shows one estimate of the cost of distributing one dollar's worth of several building materials from the manufacturer to the site:

Cost of Distributing Building Materials through Conventional Channels

Material	Cost of Manufacture	Cost of Distribution			Cost of Transportation	Combined Profits			Delivered Price at Site
		Manufacturer	Jobber or Wholesaler	Retailer		Manufacturer	Jobber or Wholesaler	Retailer	
Lumber	$1.00	0.23	0.33	0.54	0.34	0.21	0.09	0.09	2.83
Plaster, lath, and wallboard	1.00	.28	....	.89	.35	.53	....	.21	3.26
Insulation	1.00	.37	.09	.09	.27	.18	.09	.09	2.18
Concrete and mortar	1.00	.32	....	.18	.19	.17	....	.09	1.95

Source: *Housing Costs; Where the Housing Dollar Goes, National Housing Bulletin* 2 (Washington: National Housing Agency, October 1944), p. 46. The data on which this breakdown is based were obtained from unpublished studies of the Office of Price Administration and in general represent 1940–1941 conditions.

There are obviously inviting targets here for any sort of large house-building enterprise, and this is one point where the largest operative builder, along with the largest prefabricator, has had a degree of success.[2] It is difficult to define the degree to which many prefabricators succeeded, because at the time of the survey they were not able to buy under what might be called "normal market conditions." It may be said, however, that only a few companies were able to effect really substantial economies in their materials purchases, and almost none had effected all those which they thought they should have. Even so, it is true that the industry's dozen largest members had, for

[2] See, for instance, the talk by William Levitt to The Producers' Council, October 1947, reported in *The Architectural Forum,* 87 (November 1947), 10, and in *Journal of the American Institute of Architects,* IX (June 1948), 253–6; and the rebuttal letter by H. M. Long in *The Architectural Forum,* 88 (January 1948), 18. See also the builders' and manufacturers' points of view as presented in testimony before the Joint Committee on Housing of the 80th Congress, *High Cost of Housing* (Washington, 1948), pp. 127–30.

the most part, been able to buy directly from the mills, or in some cases where they had been frustrated in their attempts to do so, they had begun to manufacture materials themselves, acquiring lumber mills and even engaging in logging operations. Most of the small manufacturers, on the other hand, were not established in volume or reputation and were finding it very difficult to secure accounts with direct sources. During the Veterans' Emergency Housing Program it was expected that the prefabricators would be able to buy directly from the mills, but after the program ended a number of mills refused to sell directly any longer, with unfortunate results for some of the smaller companies. This refusal is not difficult to understand. Under the VEHP allocation program of 1946–1947, 300,000,000 sq. ft. of plywood was shipped to prefabricators during a one-year period at the direction of the government.[3] The mills did not believe that the prefabricators were able to use more than ⅔ of that amount,[4] and some sources [5] put the figure as low as ⅓. By late 1947 and during the first half of 1948, the situation had changed substantially, and many prefabricators reported difficulty in securing sufficient plywood at "reasonable" prices.

It is estimated that half of the 37,400 prefabricated houses produced in 1947 were constructed chiefly of plywood. The industry's consumption of this material in recent years is shown in the following table:

Estimated Consumption of Softwood Plywood, 1946–1948

(millions of square feet, ⅜" equivalent)

	1946		1947		1948	
	Estimated Consumption	Per Cent of Total	Estimated Consumption	Per Cent of Total	Anticipated Consumption	Per Cent of Total
Prefabricated houses	70	5.4	100	6.3	150	8.3
Other residential construction	459	35.8	643	40.6	731	40.6

Source: U. S. Department of Commerce, Construction Division, *Construction and Construction Materials; Industry Report* (April 1948), p. 7.

[3] Source: Douglas Fir Plywood Association, in a letter to the Bemis Foundation, August 21, 1948.

[4] *Loc. cit.*

[5] *Construction and Construction Materials; Industry Report,* U. S. Department of Commerce, Construction Division (April 1948), p. 6.

Corporate integration reaching back to the raw materials stage was observed in quite a few instances, particularly among those firms working with wood. At least 14 prefabricators were cutting their own timber or were closely affiliated with logging operations, while 38 companies were known to have equipment for various aspects of lumber manufacture. Two of the companies producing houses or house components (General Plywood Corporation and Buffelen Lumber and Manufacturing Co.) were also producing plywood, and others were trading peeler logs cut on their timber stands for the final plywood product. Other examples of this type of integration include the purchase of a sheet-steel mill by Borg-Warner for the production of its Ingersoll Utility Unit, and such tie-ups as that between Precision-Built and Homasote or between Lustron and Chicago Vitreous Enamel.[6]

Another sort of integration which at least five prefabricators utilized in the procurement of materials was the establishment of subsidiary wholesale lumber and supply companies, which made it possible for them to buy material and equipments at the lowest possible prices.[7] Many of the companies, as has been pointed out in the chapter on management, started as, or were backed by, lumber companies and so were able to enjoy this advantage without the necessity of setting up separate purchasing entities. At least 30 companies were in this category. As might be expected, some of these subsidiary purchasing organizations found it expedient to sell on the open market as well. Not only did they sell materials which they had bought in excess quantities, but they also served as outlets for items such as doors, windows, or cabinets which their parent companies might have produced in excess in conjunction with their house packages.

This sort of subsidiary purchasing organization was established by Ivon R. Ford, Inc., after the war for its own use, and that of nine licensees in various parts of the country, under the direction of Guy C. McKinney in Washington, D. C. In 1947 this purchasing subsidiary became an independent organization, and its services were made available to the entire membership of PHMI. Purchasing powers were pooled, and McKinney & Co. was able to arrange with materials and equipment producers for large orders on a steady basis.

[6] Precision-Built was a subsidiary of Homasote Company and made extensive use of its materials. Similarly, the Lustron Corporation was in its early days a subsidiary of Chicago Vitreous Enamel Product Co.

[7] Texas Housing Co., California Prefab Corp., Ivon R. Ford, Inc., Brady Construction Co., and Claude T. Lindsay, Inc. The savings made by Levitt on Long Island through such a device have been well publicized.

It was hoped that these producers might become, in effect, "permanent suppliers" of the service, which would receive its income from a monthly fee paid by participating companies. Although such a service might have been a boon, especially to smaller operators whose activities had been severely curtailed before participation by inability to purchase sufficient materials at reasonable prices in that confusing period, it did not work as planned. During its existence the service paid mill prices or slightly more for the materials and equipment it bought but, in most cases, less than the wholesale price. Dimension lumber, for instance, was furnished at less than wholesale quotations, and kits of electrical fixtures were bought at savings of 35%, 40%, and even 50% over local wholesalers' prices.

In 1946 and 1947 there was considerable criticism on the part of the materials producers that too many prefabricators had placed orders based on huge estimates of production and that, when these estimates were not fulfilled, cancellations came thick and fast. Although confidence in the prefabricator is not the only condition that must obtain before a materials producer will be willing and anxious to sell direct to him, it is one of the most important ones, and the prefabricators were anxious to achieve it.

II. Finished Material and Equipment

Apart from the structural shell fabricated by the house manufacturer there are various components which he seldom if ever fabricates, but rather buys in large quantities to furnish with the house package. There are several reasons for his doing so. One is the possibility of supplying these items to the ultimate consumer at costs lower than those the consumer would have to pay; generally speaking, such economies as were obtained in this way were very modest, although in several instances they were considerable. Another reason is the advantage gained from marketing as complete a package as possible. Most of the advantages accrue directly to the dealer-erector, however, and only indirectly to the prefabricator. They include, for instance, the time saved the dealer in procuring his materials, and the elimination of wastage at the site through the use of the proper amounts

of material. Such advantages were particularly important during the period of the survey, which was one marked by frequent shortages and irregularities in materials flow. The prefabricator was not always in a position to help his dealers in this way, but when he was, the savings obtained constituted real economies to the dealer and probably more than offset the prefabricator's storage and handling costs. Thus costs were lowered even if purchasing was not done at particularly advantageous prices.[8]

A further reason why the prefabricator may strive, by acting as a jobber, to furnish as complete a package as possible is that by so doing he enables his dealer to make a larger dollar sale and thus to obtain a larger profit. Of course, there is also the opportunity for the prefabricator to take a substantial middleman's profit, and many did so.

Number of Companies Known to be Acting as Jobbers for Various Finished Components

Item	*Regular Part of Package*	*Optional*
Electrical fixtures	26	6
Flooring	58	16
Furnaces	50	9
Heating stacks	25	3
Hot-water heaters	41	8
Kitchen cabinets	73	6
Plumbing fixtures	31	12
Refrigerators	10	5
Roofing	70	4
Screens	43	12
Stoves	13	7

The table above gives the number of companies known to be acting as jobbers for various finished components. That there were not more companies furnishing plumbing assemblies and electrical fixtures was largely due to the fact that prefabricators wished to make it possible for their dealers to subcontract plumbing and electrical work. Such equipment is customarily sold through the contractor who installs it, and most contractors were understandably reluctant to install fixtures included in a prefabricator's package when in so doing they would lose their selling profit. Since these contractors had plenty of regular business, and since the prefabricator was often new

[8] Note that savings through simplified purchasing and elimination of waste have also been the objectives of the "industry-engineered house" program and the proposed program of the Research Institute for Economic Housing, New York City, Spring, 1948.

to them, it was frequently necessary for the prefabricator to eliminate certain items from his package in order that his dealer-erectors might establish successful working relationships with the local contractors.

A second factor that sometimes entered the picture was the refusal of some local unions to handle such items as preglazed sash and prehung doors. Few prefabricators, however, mentioned this as a major difficulty. Another factor that affected the activities of some prefabricators as jobbers was the choice of marketing pattern. One firm which was planning to sell through department stores said that it would have been able to furnish refrigerators with its house packages at 60% of the retail price, but that it could not do so for reasons connected with the merchandising policies of its outlet.

Considered as a whole, prefabricators were not achieving substantial economies by acting as jobbers, even though they may have bought in carload lots. Thus, much the same situation obtained in their procurement of finished materials and equipment as in their procurement of raw materials. Generally speaking, the "average prefabricator" in his role as a middleman was able to offer his dealer prices which were the same as or only slightly lower than would have been paid to the regular distributive outlets. The mere fact that a prefabricator might be classified by some as a manufacturer rather than as a builder did not, it seems, entitle him to a special discount. This was particularly true after the Veterans' Emergency Housing Program ended when, as in the case of raw materials, some producers of home equipment refused to continue selling to house manufacturers at factory or even wholesale prices. One prefabricator who had been furnishing along with his house a certain shower unit that retailed for $65 had, during the VEHP, been able to buy the unit direct from the manufacturer for $21, and supply it to his customers for $35, installed. After the expiration of the program, the manufacturer declined to sell the unit in any way except through the intermediary of wholesale and retail plumbing houses.

There were a number of cases that differed markedly from the "average"—cases in which prefabricators had sufficient volume of sufficient power to obtain real savings in their purchasing. One of the largest firms in the industry stated that its experience showed net savings in finished materials and equipment costs of about 35% over small conventional builders. Another company which did somewhat less business, but was affiliated with a very large materials producer, reported that it was buying its jobbed materials at industrial discounts and selling them to its dealers at a 15% mark-up. Hot-water heaters which retailed at $150 were bought by this company at $44.

An eastern company stated that it had been quoted unit prices on a set of kitchen cabinets of $48 per set. If, however, it had ordered 10,000 units, the price would then have been only $17 per set. The same firm estimated a saving of $1,000 per house through such mass purchasing if production volume were raised from 100 to 21,000 houses per year. A study of the proportion of the final cost of finished materials and equipment that is represented by distribution costs confirms the opportunities afforded for savings by direct purchasing:

Cost of Distribution of Finished Materials and Equipments through Conventional Channels

Finished Material and Equipment	Cost of Manufacture	Cost of Distribution			Cost of Transportation	Combined Profits			Delivered Price at Site
		Manufacturer	Jobber or Wholesaler	Retailer		Manufacturer	Jobber or Wholesaler	Retailer	
Finish hardware	$1.00	0.17	0.35	0.48	0.10	0.14	0.07	0.14	2.45
Plumbing	1.00	.03	.22	....	.10	.05	.11	....	1.51
Heating	1.00	.10	.17	.07	.10	.06	.08	.02	1.60
Electrical	1.00	.18	.85	....	.13	.13	.10	.13	2.52

Source: *Housing Costs; Where the Housing Dollar Goes*, p. 46.

In light of the potentialities for cost reduction offered by direct purchasing, one might well ask why prefabricators have not been generally more successful in cutting their finished materials and equipments costs. The problem involved here is not one peculiar to the prefabricators. It confronts the building industry as a whole and is a crucial one in the evolution of large building enterprises of any sort, whether of operative builders or of prefabricators. One conclusion that has emerged out of almost every study of the building industry in the last decade is that few if any of the industry's problems cannot be traced in some way to the small scale on which operations are carried out; yet, when a building organization begins to grow to a really significant size, it still cannot obtain many of the advantages and efficiencies which ought to go with its stature. This has been the protest of many of the big builders, of whom Levitt of Long Island has been perhaps the most vocal, and it has also been the protest of many a prefabricator. Even though prefabricators buy materials in carload lots and even though they carry out most of the functions which normally fall to the middlemen in the regular distributive chain—principally stocking and maintaining a sizable in-

ventory, handling, sorting, grading—they still cannot, in most cases, obtain mill prices. The reason is fairly obvious. Every time a prefabricator buys at the mill, and at mill prices, at least one and perhaps two elements in the distribution channel (the wholesaler or jobber and the retailer) have been completely by-passed. The mills have established stable business relations with their distributors, and they are naturally not in a hurry to upset things by circumventing them; the conventional building industry is based on the existence of these long distribution lines. If prefabricators were producing 50% of the housing in the United States instead of 5%, they would be so large an element that the materials producers could hardly afford to ignore them. But until the industry acquires that stature and until the firms who produce more than 1,000 houses a year account for a major portion of the annual building output, it is probable that the materials producers will feel obliged to rely upon and support the conventional distributors. The early phases in the development of big builders are therefore likely to be the slowest.[9] The importance of the large-scale Lustron endeavor is great if from no other point of view than this. As more big housing producers emerge, they will tend to become an increasingly significant element in the industry, and the small builder, to whom the present materials distribution scheme is well suited, may tend to become increasingly unimportant. Neither trend was conspicuous at the time of the survey.

III. Fabricated Components

In a manufacturing operation which consists largely of assembling fabricated components purchased from specialized producers, the

[9] *The Architectural Forum* feels that this trend is already established. In the November 1947 issue, on page 10, it reports that its research, based on building permits issued in 1946 and 1947, indicates that builders of 10 or more houses a year presently account for three-fourths of all United States house construction, whereas nine years before they accounted for less than half the houses built. However, this statistic should not be interpreted without considering the fact that housebuilding in 1946 and 1947 was proceeding at about twice its rate in 1938; furthermore, there is a big gap between the builder of 10 houses a year and the builder of 1,000.

distinction between procurement and production is very tenuous indeed. This is, however, an important consideration, for not only is there the question of how much of the house should be built in a factory and how much at the site, but there is also the problem of how much of the house should be produced in a central plant and how much assembled from components of various manufacture at one or more distribution points. The distinction is between the prefabricator as a producer and the prefabricator as a synthesizer. In either case he may retain the functions of design and integration and of distribution. But there are a number of other considerations which had led certain prefabricators to prefer one or the other of these different types of operations.

By producing as much as possible of the house in his own plant, the prefabricator will avoid paying for the overhead and profit of other manufacturers; he probably will have greater freedom in design; and he should have greater freedom in the administration and control of his business operations. On the other hand, some of the prefabricators visited had several reasons for freeing themselves of as much actual production work as possible. For one thing, many lacked the capital to build the necessary production facilities; this was particularly likely to be true of a proponent of a metal house. Furthermore, even if he had sufficient capital, the prefabricator might well prefer to use it elsewhere and avoid tying himself to any particular material or process. The period during which the survey was conducted was one of great flux and high technological expectations. It was natural that in such an atmosphere a number of companies avoided heavy investment in plant and equipment and replaced production with procurement so far as possible. Even in more stable times highly centralized production might interfere with an objective approach to design and deter the company from adopting new materials or structural techniques simply because these would not utilize existing facilities.

Perhaps the most obvious reasons for purchasing rather than producing certain components, however, were those of relative immediate costs. Component manufacturers might well achieve substantially lower costs than a prefabricator making the same items because of two advantages: specialized high-volume production on a steady basis, and optimum location with respect to resources. It is clear that some prefabricators did not have a large enough volume to justify the purchase of a complex glue press, for instance. Furthermore, prefabricators had to locate these plants with reference to their market as well as to such other factors as raw materials and

labor. The component manufacturer, on the other hand, worries less about the location of the general housing market, locates near the resources he uses, and thus avoids paying the transportation cost for material that is lost in component manufacturing. Also, he maintains a steadier production rate by selling to a much broader and larger market. The lumber companies thus did a great deal of initial processing for prefabricators. In the production of doors, windows, and cabinets these advantages were great enough to warrant the growth of a large industry specializing in this type of manufacture; other examples of factory-made components which were purchased by prefabricators included chimneys, stairs, and plumbing assemblies.

The decision to avoid heavy investment in specialized tools was a fundamental consideration of the Harman Corporation in determining its whole pattern of operations. Its plant in Wilmington, Del., served more as a warehouse than as a factory. There some fabrication was done, such as of wood furring strips, but the operation was generally one of storing and packaging the steel frames, panels, windows, insulation, wallboard, and plumbing and heating equipment, all of which were being produced elsewhere by other firms. In many respects the Harman operation was more like precutting than prefabricating, but the example is illustrative of the assembly operation. The HomeOla Corporation carried out a large share of its manufacturing by subcontracting to firms near sources of supply. A large Tacoma, Wash., lumber company assembled the modular floor, wall, ceiling, and roof panels from its own lumber and plywood and shipped these parts directly to the dealers. At its own plant in Chicago, HomeOla manufactured some of the plumbing and equipment, assembled the heavier steel items produced by affiliated firms in the area, and shipped this portion of the house package to the local dealer at the same time that the wood portion was being shipped from Tacoma. One Oregon prefabricator estimated that it would entail about $75,000 in woodworking machinery and about $35,000 in assembly equipment to tool up for the production of stressed skin panels, and largely on the basis of this estimate decided to subcontract his panel manufacture to one or more established manufacturers in the region. On the opposite side, it can safely be said that the tight capital position of Anchorage Homes, Inc., resulting from the expenditure of an estimated one million dollars for a new factory, was a major factor in its failure.

It is unnecessary to adduce further examples. As has already been pointed out, even those companies which fabricated the entire shell did not begin to manufacture everything in the complete house

package. There was no prefabricator who manufactured his own water closet or heating unit, for instance. There were a few steps in the direction of corporate integration, and there seemed to be an interest in housing on the part of some of the largest steel companies to parallel their general integrated expansion in the production of consumer goods. At the time of the survey, however, no housing analogue to the Ford Motor Company had appeared.

Part II.

Chapter 9

PRODUCTION

I. Plant Facilities

This chapter describes and analyzes the production operations of the industry, taking into consideration the physical plant capacity, the labor force employed, and other factors related to the amount of total output. A description of some of the aspects of factory production follows: the processes and equipment used, the plant layouts, the scheduling, etc. Since the production aspects of particular kinds of prefabrication have been well treated elsewhere,[1] the chapter describes only the general patterns of the industry's production operations, discussing the reasons for some of the different patterns observed. A brief economic analysis explores such questions as the quantity of manufacturing done by the prefabricator, the relationship between costs and volume, the increase in productivity resulting from prefabrication, and the cost structures typical of various groups in the industry.

One sign of the stature of the industry is its growth in productive capacity. In early 1948 this was estimated by PHMI as 120,000 houses per year, or more than three times the actual production. For the bulk of the industry, however, it is known that estimates of physical capacity at any time are not too significant because the tooling-up costs are not high. The creation of capacity for the early war housing and for the 30,000 houses which were to have been produced under lend-lease in 1945 are examples of rapid expansion under stimulus. It should also be noted that this estimate of 120,000 excluded many of those companies which had adopted unconventional approaches and were committed to highly mechanized operations involving large investments in plant and equipment. In the spring of 1948 the National Association of Housing Manufacturers, representing these firms, estimated that if the potential capacity of its membership were realized, it would exceed the then existing capacity of the rest of the industry.

The value of plant and equipment of 40 member companies surveyed by PHMI in 1947 was $11,008,467, and the total assets of these companies were more than $24,000,000. Although this was

[1] Particularly in the *Manual on Wood Construction for Prefabricated Houses.* See also N. S. Perkins, *Construction Manual for Douglas Fir Plywood Dri-Bilt Houses* (Tacoma: Douglas Fir Plywood Association, 1940).

less than half of the $60,000,000 estimated total capitalization of the industry, most of the balance was represented by the giant Lustron Corporation. It is interesting to note, by way of comparison, that by June 1948 Lustron alone had already contracted for some $12,000,000 worth of plant and equipment, an investment greater than the 1947 total of the 40 firms mentioned above.

During the Bemis Foundation survey, the average size of plants larger than 100,000 sq. ft., of which there were 16, was 223,000 sq. ft. This does not include the Lustron plant, of which the floor area was more than 1,000,000 sq. ft. The survey also revealed that 29 companies had completed new plant facilities since the war, and that at least 22 more were planning or actually building new plants.

On the other hand, there were numerous companies, a great many of which were not visited, which operated with quite primitive equipment: a small shop or shed, some crude wooden jigs, and a few power saws. Though they would have to be classified as prefabricators, these firms were probably operating on a capital investment about the same as that of a conventional builder with the same output.

There were 19 companies which had more than one plant facility. In most of these cases, one or more of the plants was a materials preparation or cutting organization near the source of supply. Several eastern firms had a lumber-producing and precutting plant in the South and an assembly plant in the eastern seaboard area, for example, Johnson Quality Homes, Inc.

II. Location of the Industry

The map (see Figure 34) shows the location of the plants of 82 firms reported to be in operation on January 1, 1948. It can be seen that the industry was well represented throughout the eastern half of the country and on the Pacific Coast. Relatively few firms were found in the plains and mountain areas where the population is widely scattered. The largest number of prefabricators were located on the Pacific Coast and in the Midwest.

Some of the reasons for this pattern of industrial location are immediately obvious, but it may be worth while to explore the pos-

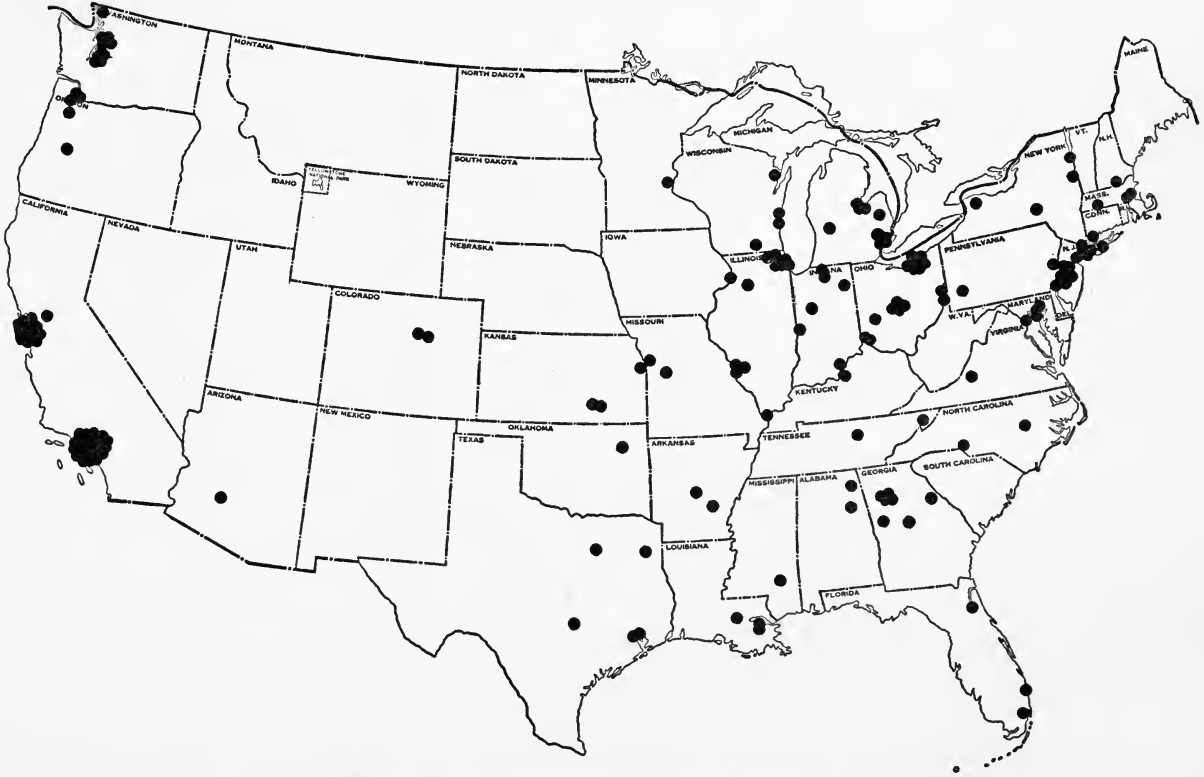


Figure 34. The Location of Prefabrication Plants in 1948

sible effects of a number of factors: access to raw materials, access to markets, access to labor supply, environmental hostility, and "accident." Regarding the first of these, there is no overall pattern of proximity to raw materials. It is true, as pointed out previously, that there were 19 companies with two or more production facilities, one of these being, in most cases, a raw materials processing point near the source, but a very large number of firms were located at considerable distances from their respective sources, whether these were of lumber, plywood, steel, or aluminum. This may be explained by the fact that the prefabricator's operations did not, as a rule, significantly reduce the weight of the materials going into his product (although his product was often significantly lighter than the conventional) and, in most cases, did increase the total bulk. There is an advantage, therefore, in being closer to the market than to raw materials.

The weight and bulk of the house package make the transportation problem such that the location of the plant relative to the market was of primary concern. Although house packages have been shipped as far as 1,000 miles and beyond, the vast majority were not transported more than 300 miles for reasons of cost.[2] We might thus expect that prefabricators were serving local or regional markets rather than national ones and that they were located close to where houses were being erected; therefore they would be generally distributed according to population over the country. In view of the ease of entry into the industry and its fluidity at the time, we might further expect that they were concentrated in areas where the building activity was greatest, and to a large degree this was the pattern observed.

If the concentration of plants is compared with the 1946 volume of new private construction,[3] the results show surprising agreement in all but three regions. The concentration of prefabricators in the Pacific Coast area and in the middle western states of Wisconsin, Michigan, Illinois, Indiana, and Ohio appreciably exceeded the relative volume of new private construction, whereas in the eastern states of New York, New Jersey, and Pennsylvania the reverse was true. Tending to favor prefabrication on the Pacific Coast were the strong expectation of future markets based upon trends in population migration, the rapid rate of growth of the metropolitan areas within which substantially all the plants were located, and the predominantly

[2] See Chapter 6, Marketing.

[3] *Construction and Construction Materials, Industry Report, Statistical Supplement,* U. S. Department of Commerce (June 1948), p. 6.

single-family, open type of development which characterized the area. The middle western states offered a mass market distributed in urban concentrations of various sizes throughout the population heart of the country, and a somewhat more receptive environment than in most of the eastern states. Possibly the Middle West was more receptive because some of the earliest ventures happened to start there and have since proved themselves and demonstrated the case for prefabrication; for those companies which came later, the struggle with external obstacles was progressively easier and the number of economic and other aids [4] progressively greater. In the eastern states the expectation of future growth could not be compared with that of the Pacific Coast, and furthermore, the population was largely concentrated in a few highly developed metropolitan areas where a smaller proportion of new private construction was in single-family houses. General consumer resistance to the idea of prefabrication in houses appeared to increase in the far eastern states, so that perhaps the greatest effort to conceal the prefabricated nature of their houses was made by companies which had plants located in New England.

The consideration of character of labor supply did not seem in many cases to be an important one in fixing the plant location, although several companies avoided highly unionized urban areas. One reason for this is the relatively low proportion of the total house package cost that was represented by direct labor cost. Another is the fact that few special skills are needed in the average prefabrication plant. Neither can plant location be explained exclusively as the result of rational calculus. Personal preferences have been the determining factor in more than one case.

Although there were some companies with two or more plants, no company had a series of branch *assembly* plants. Serious interest, however, was expressed by 11 manufacturers in the idea of branch plants, not to carry on the full range of operations typical of a single prefabrication plant, but to assemble components fabricated in one or more main factories and left unassembled there for the sake of economical shipping, and to act as warehouses for house parts comprising a variety of designs. The principal difficulty was that an investment in a chain of final assembly and warehouse facilities in order to achieve wider and more economic distribution would require more capital than any company had been willing, or than most had been able, to risk thus far.

[4] For example, a concern specializing in transporting prefabricated houses.

III. Labor Force

Statistics concerning the labor force must be interpreted with the seasonal variations of the industry in mind. Even after prefabricators have moved a considerable portion of the building process into a factory, they are not completely independent of the weather. The site has to be improved; foundations must be prepared; and some time is required to shell in the house—almost always at least a day and sometimes several days. As a consequence of factors such as these, the prefabricators have been only partially successful in overcoming seasonal fluctuations, although there is reason to believe that if dealers are trained and well enough capitalized to do more work in advance, and if the proportion of site work decreases, these fluctuations will become smaller and smaller. It was the experience of Gunnison Homes, for instance, that the active building season had been extended by one and one-half months at each end, and it was this firm's belief that it would be extended further. It should be pointed out in this connection that Gunnison and a good many other firms in the eastern and middle western states were attempting to stabilize their factory operations by shipping house packages to dealers in the southern states during winter months.

If one bears in mind the seasonal influence and the fact that many of the plant visits were made during winter months, some idea of the size of the labor force can be obtained. For the industry as a whole, this was in the neighborhood of 10,000 at the time of the survey.[5] In those plants actually in production when visited, there was an average employment of 79 workers. Similarly, the 1947 PHMI survey found a total of 2,810 factory workers employed by 40 companies in January 1947, an average of 70 workers per company;

[5] The labor force at various times was reported as follows:

Date	*Number of Firms*	*Total Employment*
September 1946	115	10,200
November 1946	102	11,630
January 1947	167	10,450

Source: U. S. Department of Labor, U. S. Employment Service, Labor Market Information, Industry Series No. 24–33, Current Supplements for October and December 1946 and February 1947.

and the Department of Labor found an average employment figure ranging from 63 to 114 at various times during 1946–1947.[6] It is interesting, and perhaps significant, that the average number of factory employees per firm, as reported by PHMI, went from 70 in January 1947 to 83 in July, to 98 in January 1948, and to 103 in July 1948.[7]

Average capacity employment of 300 workers on a single-shift basis was indicated by 24 companies; some of the estimates given may have been overoptimistic. Only one company reported more than 1,000 as its capacity employment with present plant facilities. Again, none of these figures included Lustron, whose projected output of 30,000–40,000 houses per year might call for a factory labor force of 4,000 spread over three shifts.

IV. Factory Processes and Equipment

This section describes the degree of industrialization found among prefabricators and the factory techniques in use. Because the materials used tend to be the most important factor in governing the choice of the actual production techniques and tools, they serve as the basis of organization of the discussion.

A. Wood

Wood is a material which has several advantages and a good many disadvantages over other materials in its adaptability to industrial production. Perhaps its best quality is the ease with which it can be cut, machined, and pieced together. Woodworking machinery is inexpensive, at least by comparison with metalworking machinery. It is therefore not necessary to reach such a high volume of production in order to put an investment in woodworking machinery on an economic basis. A further advantage is that the production engineering for most prefabricating in wood is relatively simple and does not

[6] *Loc. cit.*

[7] The 1947 figures are for 40 companies; the 1948 figures, for 50 companies.

require the collective effort of a staff of highly trained technicians. On the other hand, compared to steel, wood offers a few distinct handicaps to industrial production. It is, by nature, not so homogeneous; it is dimensionally less stable; it is not so well suited to such a process as the forced drying of a paint coat; and it cannot so easily be shaped. Because of these qualities the production man dealing with wood finds it more difficult to achieve good quality control, to obtain close tolerances in dimensions, to benefit from the wide variety of industrial finishes that have been developed, and to use high-speed material-forming equipment. For these and other reasons there has long been a school of thought which holds that when real housing industrialization does come, the basic material used will not be wood.

1. Preparation and Handling of Materials

Many companies began the fabrication process with the manufacfacture of lumber out of timber taken from their own tracts. There were at least 38 companies which owned remanufacturing equipment and were capable of creating finished lumber from large timbers.

Prefabricated house manufacture requires a fair degree of precision in order to make the prefabricated components fit together readily at the site. When wood is used as the basic material this precision is not always easy to obtain, and it becomes important to control moisture content in prefabricated house manufacture where it might not be essential in conventional house construction. For this reason at least 20 companies used their own dry kilns to bring lumber to the desired moisture content before it entered the fabrication process. A number of other companies used systematic air-drying operations for the same purpose. The bowing out of plywood panels is a possible consequence of changes in the moisture content of the plywood after it has been glued into a panel, taking place when interior and exterior plies of the panel expand or contract with respect to one another to produce a curvature. One way of counteracting this tendency is to store plywood in such a way that its surfaces are free to come to moisture equilibrium with a controlled environment.[8] Although plywood was almost always stored in an

[8] It should be noted that, since the interior and exterior surfaces of a wall are exposed to different environments, they will tend to attain different moisture contents in the course of time; consequently, if a stressed skin panel is built true at

inside heated space, only a few companies were known to be following the practice of "sticking," which involves putting wood strips between the sheets when piling them. Those that did had less difficulty with panel bowing.

Only a few companies were found to be thoroughly inspecting their plywood, and indeed there was no really good test for the soundness of the glue lines. However, at least 13 companies were dipping some or all of their framing members into a toxic preservative in order to protect the wood from fungi or harmful insects. In certain sections of the country, of course, this is more or less standard practice.

The preparation of other materials was usually quite minor in extent. Insulation and wallboards usually were purchased ready to use, except for necessary cutting. Homasote, however, was wet down to cause it to expand before being used for the surface of a panel. It shrinks on drying, thus making the skin of the panel taut and in effect prestressing it.

Only a few mechanized conveyer lines were seen in use to convey lumber from storage to preparation points; this was being done by forked lift trucks in at least 16 cases, by high-bodied carrier trucks in at least six, and by gravity roller lines in two, but mostly by carts or by hand.

2. Cutting and Machining

Prefabricators using wood usually required high-grade lumber and great precision in their cutting and machining operations, particularly in the manufacture of plywood panels. In manufacturing these the framing member had to be square with the plywood surface in order to achieve a good glue bond. Additional precision was necessary at the perimeters of the panels where very accurate millwork was often called for by the construction system. Furthermore, framing members had to be quite straight, in order that they would fit into the jig positioners properly. Thus, in a good many plants, use was being made of large, high-speed, precision woodworking machinery such as circular saws of various types, single and double

a time when the interior and exterior sheets of plywood have the same moisture content, the panel may bow later on. The U. S. Forest Products Laboratory has recently been conducting research to discover the optimum initial moisture contents for plywood sheets to be used in stressed skin construction.

planers, molders, and double-end tenoners. Other tools that were sometimes found in use were multiple boring machines and multiple dado machines. Molders, for instance, which are rather specialized machines for the rapid production of framing or other stock cut to a specified pattern, were known to be in use in at least 39 plants. The design of plywood-cutting machinery showed great ingenuity, some of the ideas having been developed during the war when production often depended on the ability to improvise the required tools and equipment. A few prefabricators were using automatic cutting machinery designed and produced for that purpose by saw equipment manufacturers, but the majority of those who were doing any extensive plywood cutting had devised schemes of their own, using such elements as traveling circular saws or moving tables. In many cases it was desirable to give the plywood extremely accurate edge surfaces and square dimensions, particularly when plywood sheets were used to make up the inside wall and ceiling surfaces. To do this a double-end tenoner was often used. This machine, which sizes sheets and panels to precise dimensions, grooves panel edges for splines, cuts stock to accurate length, and does many similar operations, is one of the most versatile and one of the most expensive pieces of woodworking machinery used by prefabricators in wood. At the time of the survey double-end tenoners cost about $15,000–$20,000, and at least 14 companies were known to be using them. Another machine used for accurate edging was the equalizer, and improvised machinery for the same purpose was used in 12 cases. However, not all companies using plywood as a surface material were sizing their panels or their plywood in any way; some were content to rely on the accuracy of plywood mill fabrication to achieve reasonably good joints.

3. Subassembly

Where panels of room or wall size were being manufactured, it was common practice to subassemble the framing members for standard details such as door and window openings whose location within the wall panel was not standardized. At least 19 of the large companies utilized special jigs and tools to make up framing subassemblies for standard openings, and thereby simplified assembly operations when these were incorporated into large panels. In fact, this manner of assembly usually made it possible to use fewer jigs in the manufacture of a greater variety of wall panels.

This method was employed by Precision-Built Homes. All design and production were based on the 4″ Bemis module. Framing subassemblies for windows, doors, and floor-wall plates were made up on a set of standardized jigs. Job-lot orders based on almost any modularized design could be rapidly manufactured in panels of room size by the use of an adjustable "master" jig and the interchangeable framing members and subassemblies which were already in stock.

Several companies were carrying on an operation which might be termed the subassembly of plywood. Accurately edged 4′ × 8′ plywood sheets were joined into room-size sheets by butting them over a thin backing strip of plywood which presented a common gluing surface for the contiguous sheets atop it. A strong glue line without nails was achieved through the use of a fairly simple hot plate press only a few inches wide which was operated on a fast cycle over one joint at a time. The room-size sheets were then mounted on the framing members of their panels with good assurance that joints would not open. This made it possible to paper directly over the joints without fear of cracks appearing later.

4. Assembly

Two principal means of fastening wood pieces together were being used: glue and nails, frequently both. Hand nailing, of course, is hardly an industrialized operation, even when done under a factory roof, and it was most extensively used in those plants which produced a panelized, but otherwise conventional, wood frame house. There were, however, numerous attempts to simplify and speed up the operation. A good many companies were using spring devices which deliver a staple or nail into a sheet of plywood or wallboard and into the framing underneath when struck on top with a sharp hammer blow. A few factories used corrugated clips to assemble their framing members, driving these in from above as the lumber lay in the jig, instead of driving nails into the peripheral edges. This made it possible to run the panel through some type of edging machine without the danger of nails interfering with the process. One pneumatic hammer was seen in use, and also one crate-nailing machine, the latter for applying subflooring to 24′ long panels. Several other companies were developing various sorts of automatic

nailing devices capable of either a sequence of operations or a number of simultaneous ones.

On the other hand, a number of companies using nails to obtain pressure for their gluing operations expressed the intention of installing glue presses to replace nailing altogether. When nails are used instead of a glue press, the bond is seldom so good, and consequently certain design advantages, such as the use of lighter framing, may be lost. Other reasons for installing a press were the elimination of nailing labor and material costs,[9] and, if heat were used, especially high-frequency induction, a decrease in the time required for the glue to set. In order that these advantages be decisive, however, they must outweigh the cost of an expensive piece of equipment. Only six companies were, in fact, known to be using hot presses for gluing plywood to framing in the production of panels. Heat was applied in four of these cases by high-frequency induction, and in two by heated platens, one using steam for this purpose and the other electricity. The largest hot press known to have been in actual use was Prenco's, which had a $32' \times 9'$ bed.

Being the newest of the developments, the high-frequency induction technique was the one which had aroused most interest. Its most frequently cited advantage over other types was the speed and accuracy with which heat could be concentrated at the glue lines. It could do this because the high-frequency electric field is able to focus heat at a point well within the mass in which it is oscillating, whereas the hot platen press depends on conduction of heat inwards from the contact surfaces. One of the electronic presses being used in the Midwest was bonding panels in about a minute, whereas the steam-heated press required a three-minute cycle. Such a comparison, however, is not particularly significant, because the curing time depends very much on the glue used. Generally, with either high-frequency or hot platen presses, the time required for curing can be kept to a few minutes.[10] A further device for speeding up the gluing operation was the use of a multiple opening press, such as the steam-heated one which was handling 10 panels every five minutes, including loading and unloading. Such a press cost about $35,000 in 1946, so that a fairly high production volume is necessary if it is to be used economically. In this case planned production was 16 houses per day. Other presses were designed for volumes of 40 houses per day, 35–40 per day, five per day, and in one case,

[9] A not insignificant reason was the acute shortage of nails during the period of the survey.

[10] *Manual on Wood Construction for Prefabricated Houses*, p. 179.

only three per day. In the last two cases high-frequency machines were employed, indicating possibly that for small, single opening presses these gave greater initial or operating economy, or both, than steam or electrically heated platen presses.[11] Rapid curing was also effected in a few cases by the use of heated chambers in which glued assemblies were placed after clamping or nailing. Only one company was known to be using a cold press in the production of plywood panels. This technique, which saw some use during the war, seems to have been too slow, and to have been generally abandoned in favor of either hot-press or glue and nail techniques.

Most factories were using hand-operated glue guns to spread glue onto framing members, although a few used glue-spreading machines which applied the glue to both sides of a frame assembly as it was fed between a pair of rollers. When panels had their surface sheets bonded on simultaneously in a press, the use of such a glue-spreading machine simplified operations considerably.

A distinguishing feature of almost every factory producing wood panels was the use of jigs. Horizontal assembly jigs determine the overall dimensions of panels without need of measurement, leveling, or plumbing, and usually also determine the locations of members or subassemblies within panels. The simplest jigs were crude wooden tables utilizing rough wood blocks to position the framing members. The more accurate and refined ones had steel tops and carefully machined stops which provided for the easy entry of framing members, their precise alignment, and the quick removal of the assembled unit. Devices used to apply pressure to framing members in order to hold them exactly in assembly position were stops activated by compressed air, cams of various sorts, wedges, and screw clamps. In designs where a high degree of precision was necessary, as when both surfaces of a wall section were to be factory applied, it was essential that the dimensions of the jig be very accurate and that the members be squarely aligned. This could best be assured with metal-based jigs, since the wooden ones had to be checked regularly for precision. At least 18 companies were known to be using metal-based jigs. In some cases rather elaborate "master" jigs were seen in use, these having a number of movable guides containing notches or comb-like teeth to position the framing members within the larger assembly. Such jigs were used where wall-size panels or varied designs were being produced, as contrasted with the use of

[11] It was possible to rent the electronic equipment and avoid a large cash outlay. This may also have been a factor.

simpler jigs in the production of a rather limited number of types of standard modular panels.

5. Finishing

The great majority of prefabricators in wood did not apply the final finish to the main elements in the shell of the house in their factories. Cabinets, trim, windows, and doors were usually sent to the site already painted or stained, but the floor, wall, ceiling, and roof were in most cases finished at the site. There were several reasons for this practice. As was pointed out previously, some manufacturers left most of the actual fabrication of the floor, ceiling, and roof to be done at the site. Many companies planned to disguise the panelized structure of their house by applying siding or shingles on the exterior and by taping joints, hanging wallpaper, or even plastering the interior. These operations were almost always done at the site, although a few firms applied shingles and siding to panels in the shop; therefore final finish coats were generally site applied.

In those cases where the wall or floor panels were completely fabricated in the factory and where nothing but painting remained to be done, it might seem at first glance most economical to do this work in the shop. A big reason in favor of doing so is the large element of labor cost in a site-applied paint job—from two to five times as much as the materials cost. However, there are at least two important technical reasons for not doing the final finish job in the factory. First is the danger of damage to the finished surface during handling and transport and the expense of trying to prevent such damage. (A partial solution to this problem would be to apply all but the last coat in the factory.) The second reason is that a slow-drying paint job means either a low production rate or else the use of a large area in the factory in which to do the drying. These problems might be avoided by the use of a fast-drying finish and a method of forced drying. Unfortunately, however, there were not available many fast-drying finishes suitable for exterior woodwork, and a subsequent site application of such finishes for maintenance purposes would be most difficult. In the forced drying of paint, the shortcomings of wood for industrialized production are again apparent: the high temperatures needed to speed the drying would have to be limited by considerations of damage to the wood through

charring or excessive loss of moisture, and of damage to the paint film by the expansion of air in the pores of the wood beneath the coating.

Notwithstanding all these difficulties, final finish coats were being applied to both exterior and interior surfaces in some factories. In many more plants the woodwork received only a sealer or priming coat, or both, on either one or both surfaces. And in a number of other factories, no finishing of any kind was being done. Where finishes were applied in the factory, the surfaces, usually of plywood, were in many cases first machine sanded with drum or belt sanders, then inspected and touched up where necessary, and sent to spray booths. A few plants were equipped with automatic spray set-ups, but most of those which did any spraying used manual equipment. It was customary to use a conveyer line in conjunction with spraying and drying operations. Other means of applying coatings at the time of our survey included dipping, especially for sealers and water repellents, and brushes. Forced drying was sometimes done with banks of infrared lamps; more often, by warm air.

6. Quality Control

One aspect of factory production which should not be overlooked is inspection for quality control. Not only is this more readily done in a factory than in the field, but it is also more essential to continued business success for a prefabricator than for the average conventional builder. Because of the infrequency with which houses are bought, and because of the short-term interest of the average builder and contractor in their product, the great bulk of home-building has traditionally been carried on without the use of brand names, quality guarantees, advertising, or servicing. Along with the evolution of large operative builders and prefabricators there has been a corresponding increase in the importance of establishing a name and maintaining a reputation. Quality control is an essential element in this process, and without it even the most extensive advertising efforts may fail. Systematic attempts at some sort of quality control were observed in almost every plant, and in a few these were quite elaborate, ranging from the inspection of raw materials through manufacturing inspection of dimensions, glue joints, and machined surfaces to the final inspection of finishes.

B. Metal

Probably the best testimony to the admirable suitability of metal for industrial production is its widespread industrial use. The reasons are not obscure: metal is abundant; it can be made homogeneous to a high degree; its physical properties can be intentionally altered over a wide range; it has good dimensional stability; it can easily be formed by casting, forging, extruding, stamping, or bending; it can be welded, soldered, brazed, riveted, or bolted together; and it can be made to take a vast variety of finishes—vitreous enamel, paint, lacquer, plating, and many others. Metal can be fabricated in a great variety of ways at high speed and with excellent precision. Its prime disadvantage from the standpoint of production engineering is that metal-working machinery is generally expensive and often requires a skilled engineering force for its proper set-up, control, and maintenance. Ordinarily plant fabrication of metal structures requires a larger plant investment than for wooden structures, and production volumes must be accordingly higher before economies are apparent.

The production of metal houses is described in less detail than that of wood houses chiefly because there were many fewer firms producing them, and there was but little evidence of a general pattern of factory operations. One other general remark is pertinent: most of the metal house packages do not leave the factory in the form of wall, roof, and floor panels as do wood houses. Only two firms were known to be shipping fully assembled wall panels. Most of the packages consisted essentially of separate frames and cladding, the houses being primarily of frame assembly design.

1. Material Forming

Practically all the metal systems known to have been in production utilized some sort of sheet steel or aluminum as the primary material, both for framing members and for claddings. Even the most complete production systems began with the purchase of rolled sheet metal. Flat sheets were punched and sheared as required, and then sent into forming operations. The Byrne Organization and Harman Corporation bought structural shapes already fabricated by other companies; and load-bearing wall pans were being bought by Metal

Homes Company and The Steelcraft Manufacturing Company from the American Rolling Mills Company.

In the prefabricators' plants, materials were made into structural members, wall pans, and claddings of various sorts by the means conventionally used for cold-forming sheet metal—roll corrugating, press breaking, die rolling, die pressing, etc. Such operations generally involve high tool costs and must, therefore, be undertaken at a high production rate if unit costs are to be kept low. Lustron, for instance, had installed about 100 pieces of press equipment which cost roughly $3,000,000, but it predicated this investment on an annual production of as many as 40,000 houses. Since there are many repetitive elements in the design of this house, some of these presses were to be working at very high volume (see Figure 41).

2. Assembly

In addition to their forming processes, some plants carried on assembly operations, but these were usually of a minor and simple nature. Fox Metal, for example, bolted together channels to form I sections, and then attached connector angles to these. Stran-Steel spot-welded sections together to form rib sections. General Homes, which was one company that planned to make a complete wall panel, bonded an aluminum skin to fiberboard sheathing and then fastened this to a corrugated aluminum core. Lustron gang-welded its structural shapes into roof trusses and panelized frames, and assembled most of the elements for its bay window unit in the plant. An exception to these essentially minor assembly operations was the plan of Reliance Homes, Inc. (see Figure 42). Its scheme called for assembly in the plant of complete house sections. Plant operations included welding a basket frame of steel C channels, fastening to it the interior surface of Homasote and exterior surface of aluminum bonded to Homasote, and installing and finishing the floor and mechanical equipment. Such a pattern is comparable in many ways to that used in the production of the British AIROH house, and together these two offer the best examples of the sectional house worked out in metal.

3. Finish

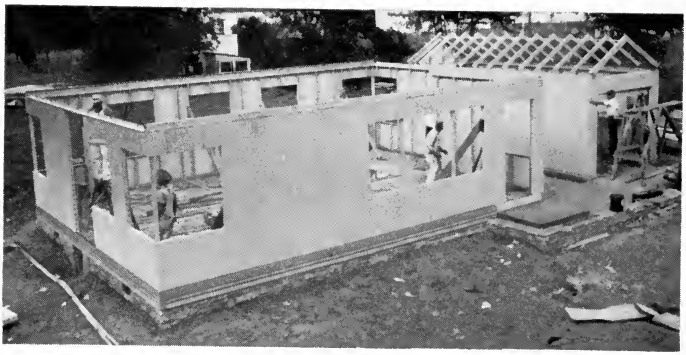
Components of metal houses generally received at least a priming coat in the factory, and often were completely finished there. With steel, rust prevention is of course a major problem, and consequently parts were primed with zinc chromate or some other paint as soon as possible. The Harman house was of steel construction to which only the zinc chromate priming coat was factory applied. Subsequent coats of oil paint were sprayed on in the field, along with mineral granules to give a stucco-like texture and somewhat improved performance.

Complete factory finishing was more common than with wood houses since the use of metals permitted accelerated drying and baking of very hard finishes. The Lustron house was one of the best examples of a completely factory-finished job, and it depended heavily on the toughness of its porcelain enamel finish to prevent damage to the surface during handling, transport, and erection. The permanence of porcelain enamel is perhaps its greatest advantage, but its application is confined to a factory where the necessary pulverizers, dipping tanks, conveyer lines, and large gas or electrically heated ovens can be located.

The Lustron porcelain enamel process was one of the important influences in the development of the Lustron Corporation. During the war, a method was developed for the low-temperature firing of porcelain enamel. This was a "one-coat one-fire" process which eliminated the base-coat operation. The process also permitted the use of ordinary steel backing rather than the more expensive enameling iron, since the lower temperature eliminated objectionable warping that would result from conventional enameling of ordinary steel.

Structural members for the Lustron house were cold formed in the plant from strip steel. These shapes were welded into wall panels and roof trusses, and each assembly was given a protective coat of enamel. The 2′ by 2′ exterior wall panels were stamped from light-gauge cold-rolled strip steel, enameled, and insulated with Fiberglas. All surfaces exposed to weathering action were given a special coat of finish enamel in addition to the basic layer. The wall panels were interlocking, and the joints between panels were sealed with a Koroseal gasket. In erection, the wall frame sections and roof trusses were bolted together and then the cladding panels applied.

35 *Ford house*

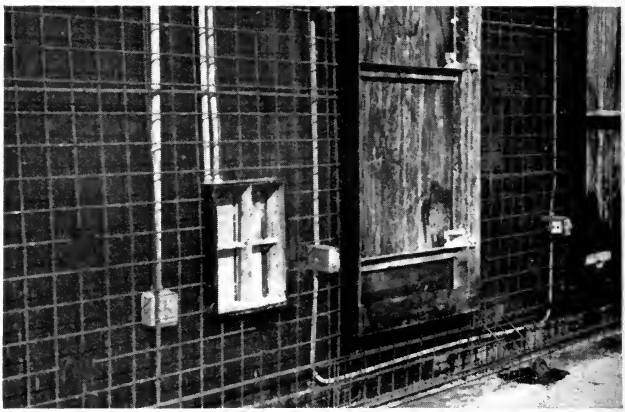


1 | *under construction*

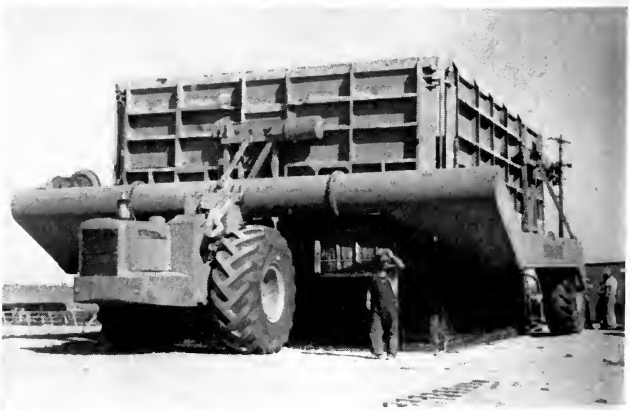
36 *Butler house*

2 | *completed*

1



2



3

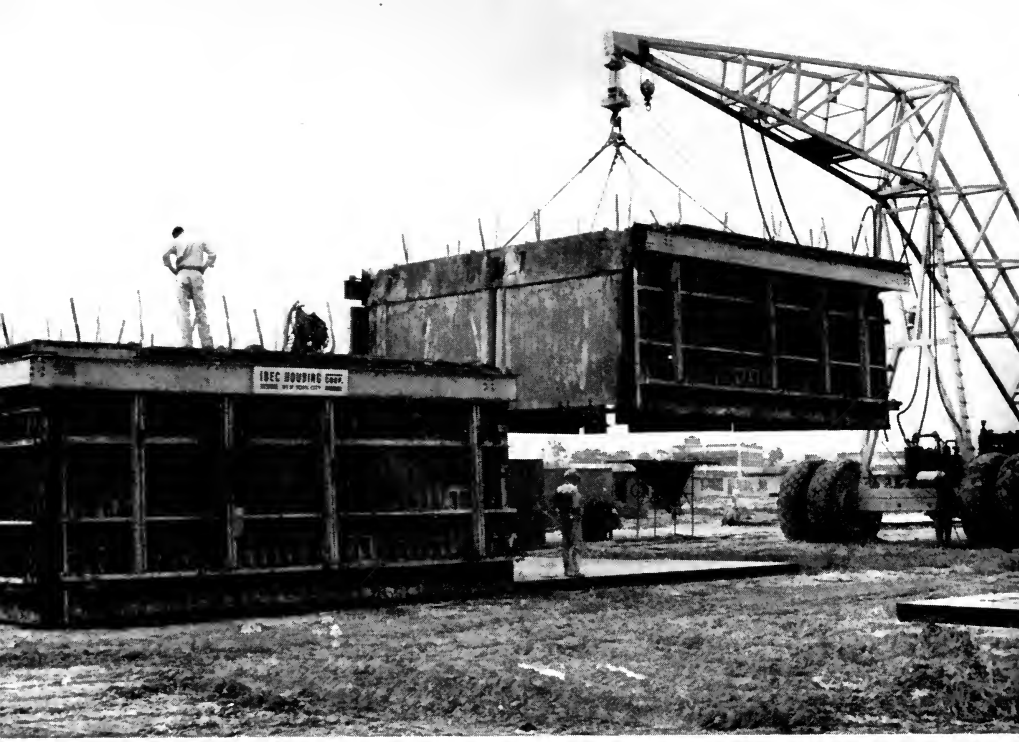
4

5

6

7

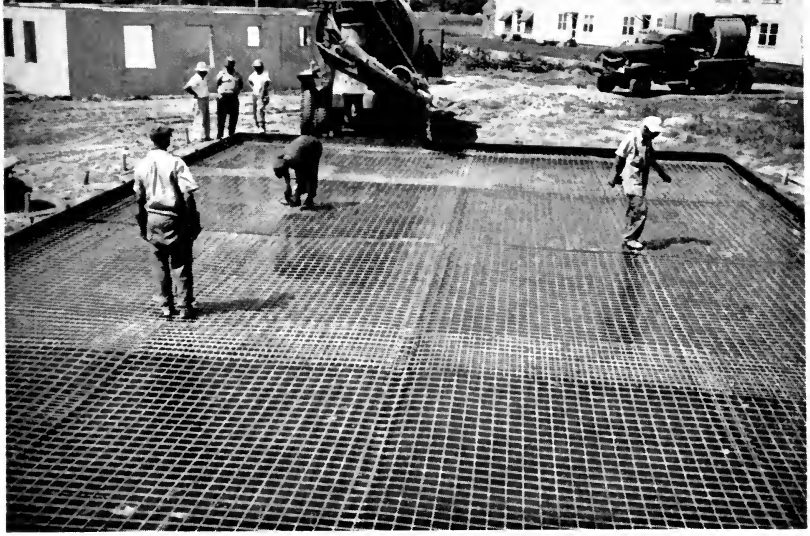
1 *basic carrier of the Tournalayer*
2 *detail of inner form ready for pouring*
3 *outer form lowered over inner form*
4 *concrete pouring gun*
5 *pouring the concrete into forms*
6 *dropping the completed house at its site*
7 *finished LeTourneau houses*



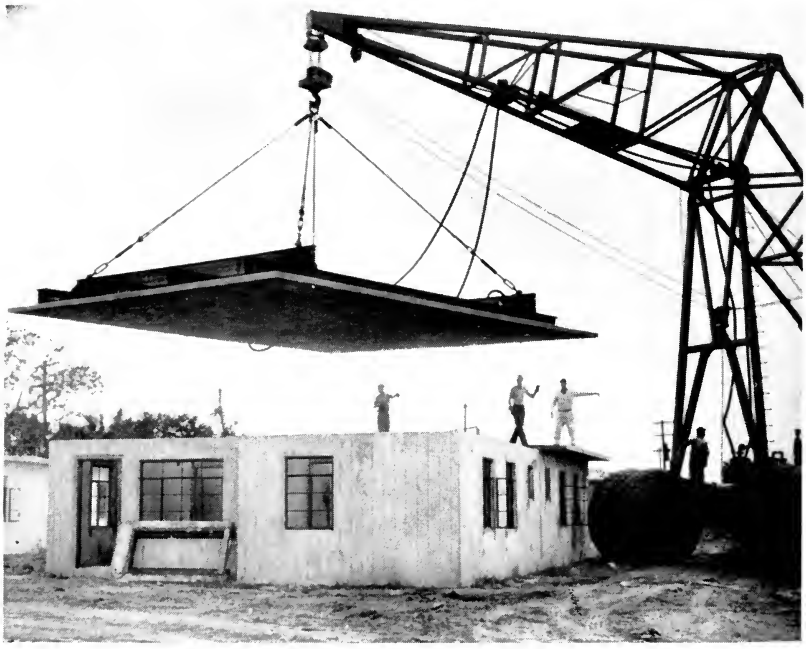
1 *placing wall forms on floor slab*

2 *pouring concrete into wall forms*

3 lifting wall forms from walls



4 *constructing roof slabs in stack*



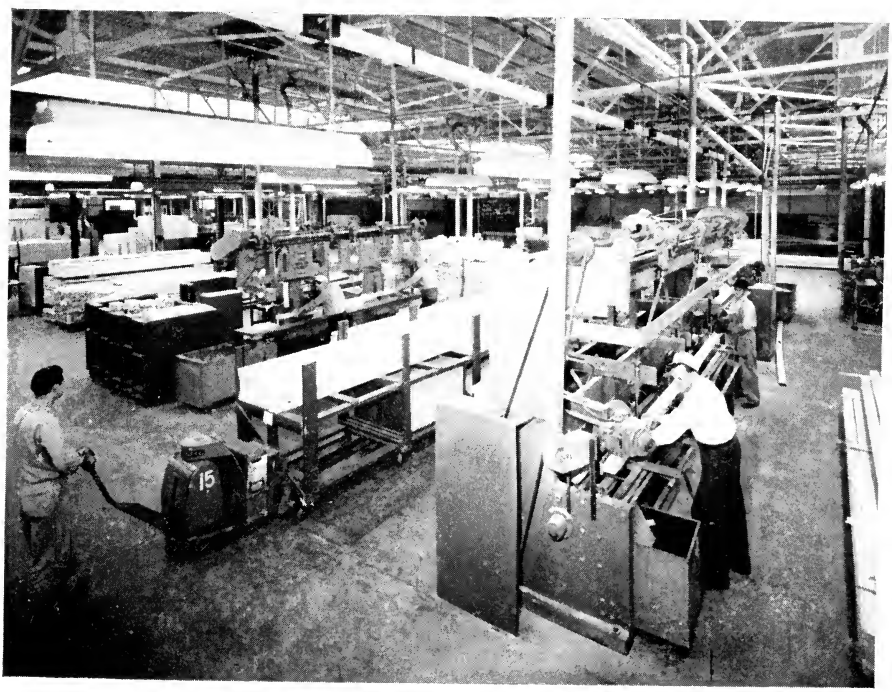
5 *placing roof slab on Ibec house*

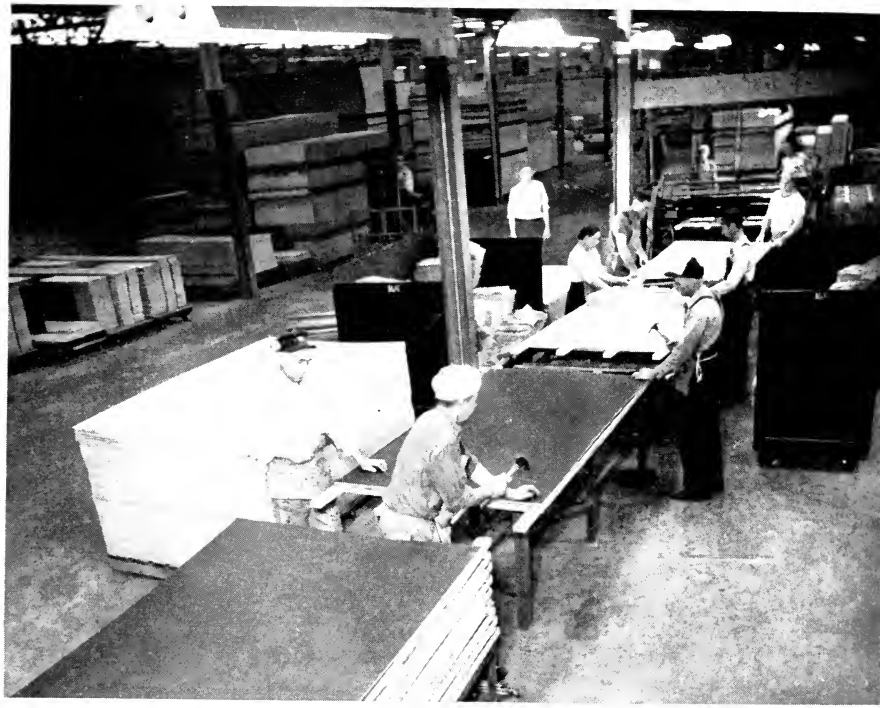
6 *completed house—Norfolk project*

1 *cutting plywood*

39 *Gunnison plant operations*

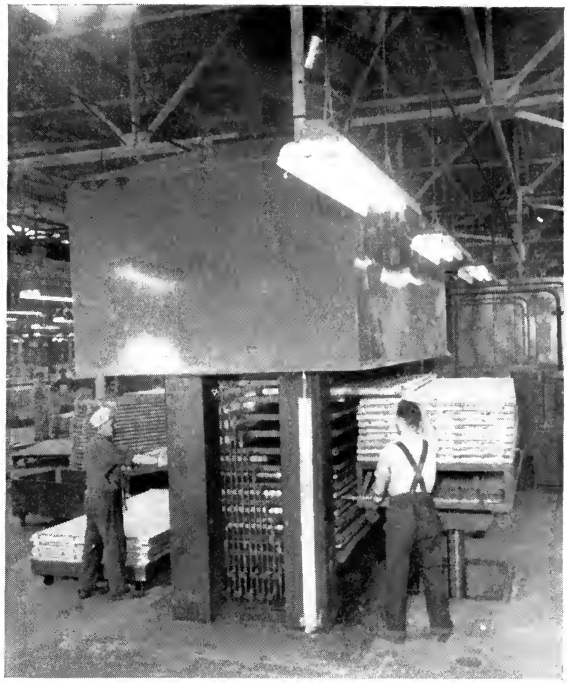
2 *cutting framing members*





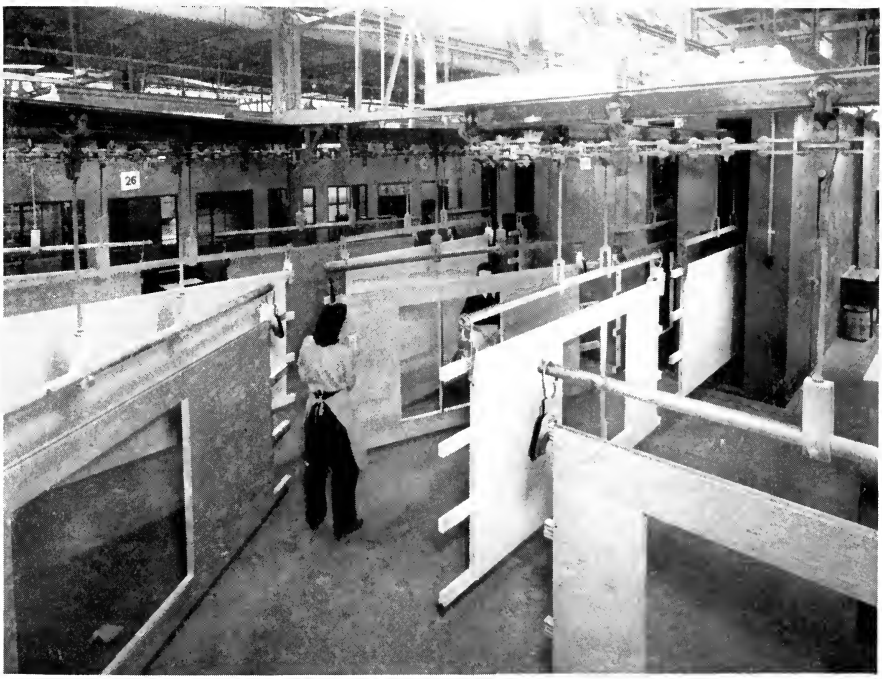
3 assembling panels for Gunnison house

4 trimming panels



5 bonding panels in multiple press

6 finishing Gunnison panels



40 *National Homes plant operations*

1 *basic wall panel line, showing from front to back: assembly of framing members in jig, spreading glue on framing members, placement and stapling of interior wallboard, application of insulation, placement and nailing of plywood exterior surface, insertion of windows and doors, and, finally, the completed panel*

2 *floor panel line*

3 *roof panel line*

4 *gable-end panel line*

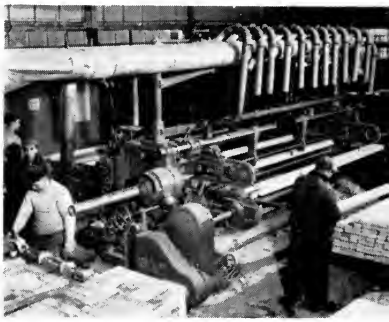
5 *special 16′ double end tenoner*

2

3

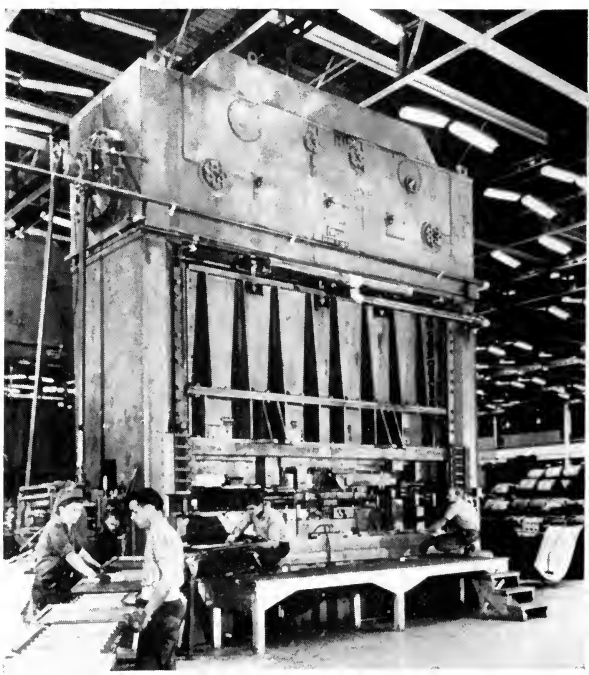
4

5



41 *Lustron plant operations*

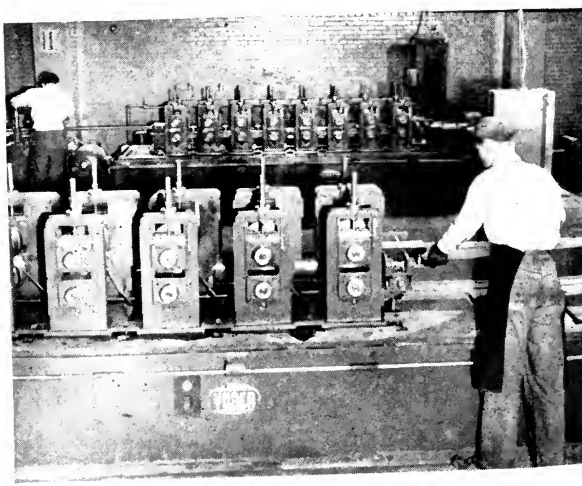
1 fully automatic exterior wall panel press

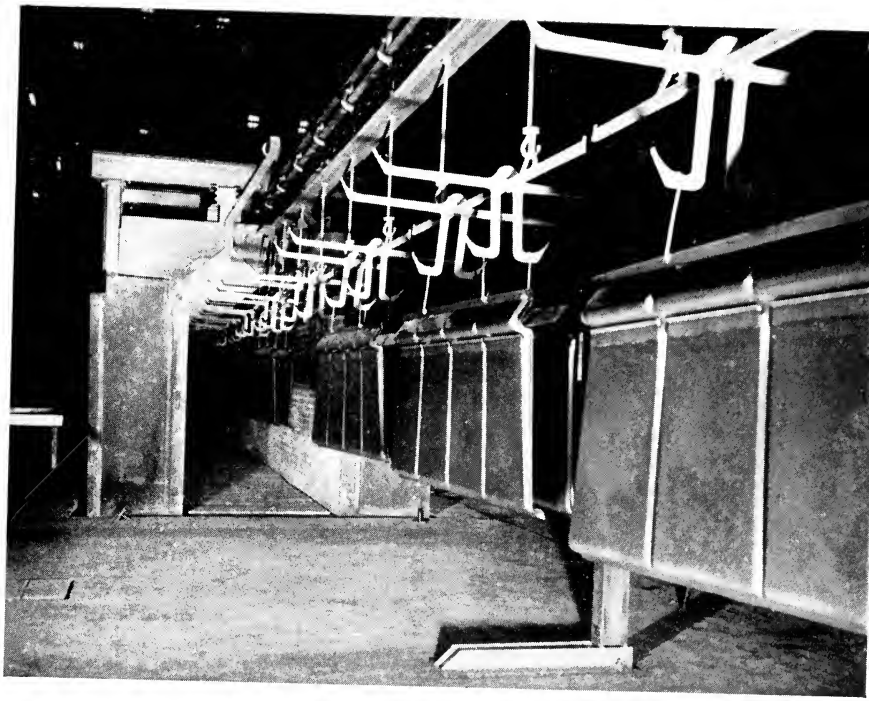


2 *grinding the frit*

3 *mixing the enamel*

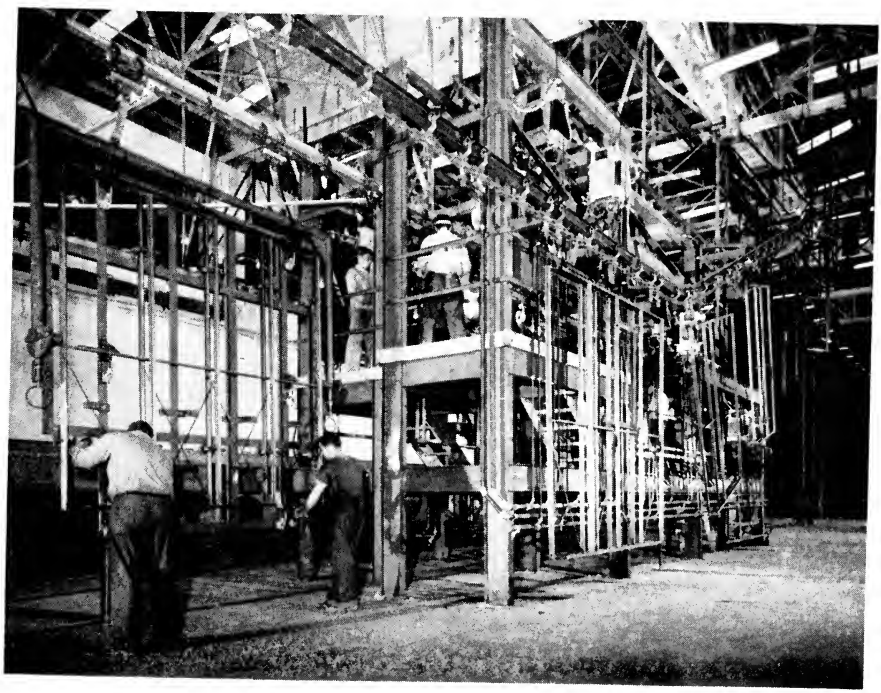
4 *rolling Lustron frame members*





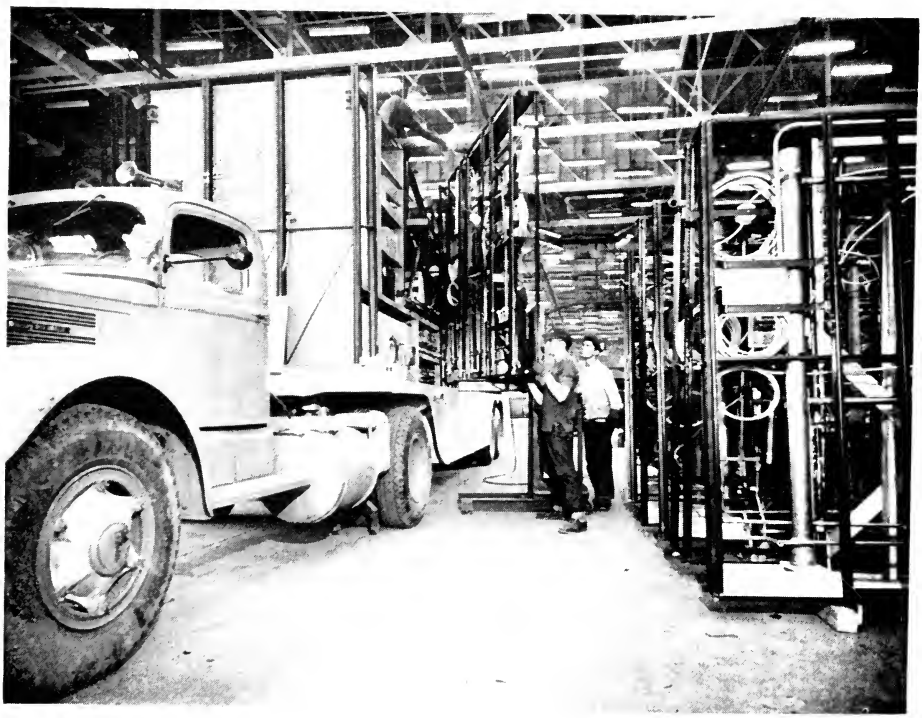
5 baking enamel on Lustron roof panels

6 welding wall frame assemblies

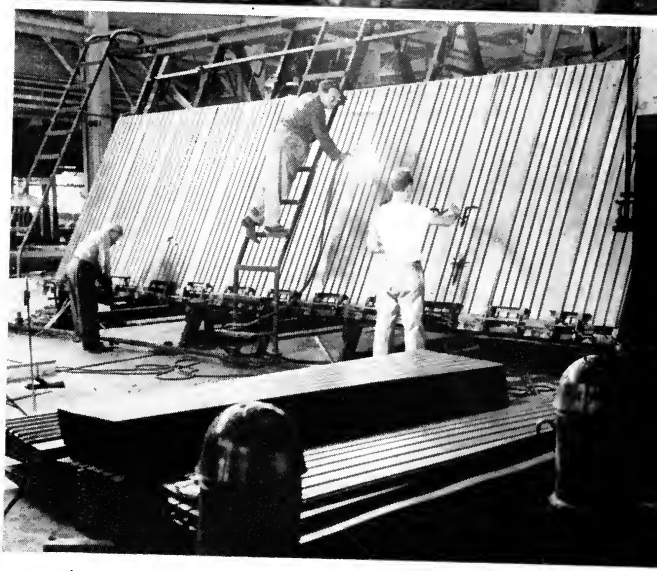


7 *loading wall panels on special trailer (note the extent of manual labor involved)*

8 *loading frame assemblies (here plumbing wall panel) on special trailer*

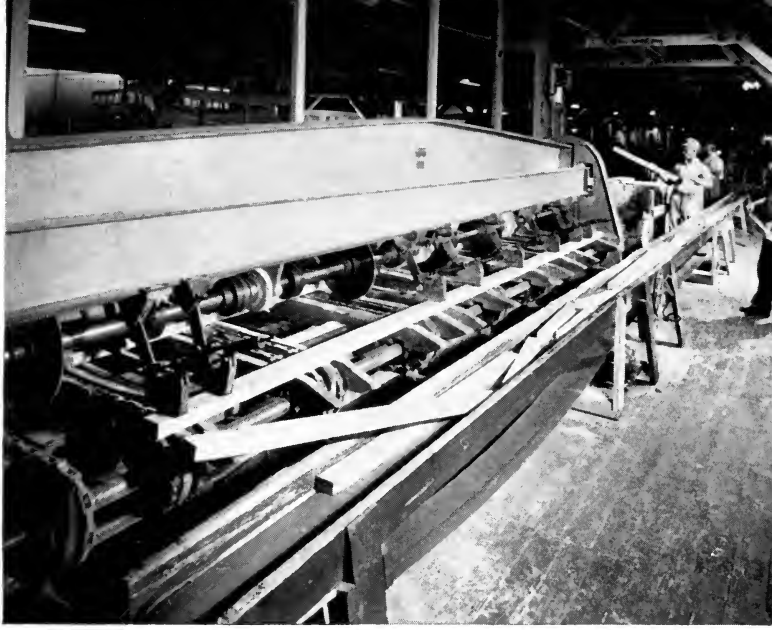


1
assembling
the
frame



2
applying
the
aluminum
surface

3
finishing
the
complete
house
sections



43 *Crawford Corporation—example of specialized woodworking machiner used by large prefabricators for multiple cutting*

44 *Texas Housing Co.*

1 | *Homette*

2 | *standard house*

1. General Qualities for Production

The theoretical advantage of concrete from the production point of view is one which exists for casting processes in general: ease of forming to the desired shape. Because of the inherent simplicity of casting, inventors have always hoped to develop materials or machinery which, using this fundamental technique, would produce a really economical house. If such a house is to be built out of precast concrete units, however, the handicaps of long curing time, frangibility, and weight must be overcome.

2. Preparation and Handling of Materials

The factory production of precast concrete units observed during the survey was characterized by the extensive mechanization of processes which were generally done by cruder methods in the field. The bulky materials used were handled primarily by mechanical batching equipment fed from rail-side hoppers or other types of loading machinery. Materials were mixed in various types of stationary mixers. Since the use of a lower water/cement ratio results in a higher strength, it was not uncommon for factory producers to mix for longer periods than would usually be encountered in field practice and to use less water, relying on mechanical equipment and better-controlled factory conditions to vibrate thoroughly and to handle a stiff mix with ease. Another preparatory operation handled in the plant, and an important subassembly process in some instances, was the cutting and assembling of the reinforcing mat. Further, the use of special mix concretes, foaming or air-entraining agents, aggregates, or methods of mixing is ordinarily more feasible in the plant than at the site.

3. Casting

From the mixer the concrete was poured into forms, which were usually of steel. Some sort of vibrating table was generally placed

beneath the steel form in order, by vibrating the concrete, to achieve more uniform densities and more precise dimensions. To put a troweled surface on the top side of the casting, some type of machine was used in almost every case.

4. Curing

In order to speed up the production cycle three methods for attaining early strength were seen in practice. Simplest, perhaps, was the use of high early strength cement, a material which becomes strong enough to withstand quite severe treatment in about one-fifth the time required by ordinary Portland cement. A second method was to pass the casting through a bath of steam under pressure. In the manufacture of the Pfeifer concrete units, for example, slabs were cured in a 36′ long autoclave while still in their steel molds. A 12-hour exposure to steam at 40 lb. per sq. in. accelerated the curing sufficiently to permit use of the molds on a one-day production cycle.

The third method, the Vacuum Concrete process, was based on the utilization of atmospheric pressure and was significant not only because of its high early strength, but also because it was helpful in dealing with several other problems of precast concrete construction. Until quite recently Vacuum Concrete had been used almost exclusively for heavy cast-in-place construction. At the time of the survey, however, it had been used for housing of precast panel construction, primarily in projects of 100 or more dwellings. Casting was usually carried out on or near the site, and although the necessary equipment could be installed in a plant under cover, it was fundamentally the same in all cases. The casting bed was of smooth concrete, so equipped that air could be exhausted from a number of grooves in its surface. When vertical side forms were placed over these grooves and the suction turned on, atmospheric pressure held the forms firmly in position. Hence they could be set and broken away simply by opening or closing air valve connections to the large vacuum pump that was the heart of the system. (Similarly, in the field, joints between precast panels were formed with the aid of flat or corner-shaped vacuum molds held in place by atmospheric pressure.) After the forms were in place the concrete was poured into the mold and was vibrated with a portable vibrator. Then one or more vacuum mats were placed on the surface of the concrete, the suction turned on, and water removed for 12–25 minutes. By lower-

ing the water/cement ratio in this way an unusually high early strength was achieved and walls cast late in the afternoon could be lifted into place the following morning. At the surface of the panel the pressure of the vacuum mat and the extraction of much of the water served to produce a particularly strong and dense concrete, thereby increasing the resistance to moisture penetration. After the mats were removed, the surface was troweled off to a smooth finish.

The same basic techniques were used for the floors, roofs, and partitions. In some cases walls were cast in a sandwich manner: 2½″ of aerated concrete would be poured first and allowed to consolidate; an equal thickness of ordinary concrete would then be poured and a slight amount of reinforcing embedded in this; finally, the top surface would be troweled with either a pigment or a ¼″ layer of white cement grout to form an exterior finish. Such a 5″ wall had ample strength and good insulation properties.

The large slabs were lifted from the casting bed by means of vacuum lifting mats which supported the weight of the slabs over their entire surface and minimized any concentration of stress such as would occur with ordinary sling lifting methods. The mats were used in conjunction with crane equipment in much the same way that an electromagnet is used to lift steel.

In precast systems in general, while it is true that special methods were seen in use for breaking slabs out of their molds as soon as possible after casting, it was nonetheless usually impossible to utilize these slabs in construction right away; sufficient time had to be allowed for them to gain the strength required in handling and transportation and in carrying the designed loads in the structure. Hence, a good deal of storage space in which the precast units could rest while aging was generally required.

5. Tournalayer

Another type of concrete construction utilized the Tournalayer, a huge machine developed in 1946 by R. G. LeTourneau. The Tournalayer was used first as an outer form in pouring a monolithic concrete house, and subsequently as a means of carrying the house to its final site. If prefabrication is defined in its broadest sense as involving the transfer to an off-site factory of a part of the construction process, the Tournalayer falls under this classification, since the work of fabri-

cating and placing the forms has been almost completely moved away from the site.

Because of the capital cost of the equipment involved and the expense of transporting it over long distances, the Tournalayer has been used only in large projects. In such projects a central operating site was selected at the same time as the housing area. Here the steel inner form, consisting of two chambered shells, was located. Prefabricated reinforcing steel, window and door bucks, electrical boxes and conduits, and separators for wall endings were placed against this inner form, and the four-sided outer form carried by the Tournalayer was then lowered around the prepared core, usually leaving a space of 5″ for the casting of walls and roof. The assembly was then ready for the concrete pour. If a high early strength concrete was used, the house could be removed from the mold within 16 hours. While still enclosed in the outside form the house was released from the core by a lever mechanism which pulled in the sides of the core about 2″ all around. Outer form and house then were raised over the top of the core by the Tournalayer and carried off. At the near-by site, slightly excavated to receive the bottom edge of the wall slab (which had been tapered outwards to serve as a foundation wall), the Tournalayer lowered the house into its permanent position. The outer form was then expanded, raised, and carried back to the casting site by the Tournalayer, leaving the house ready for finishing details. The typical house produced by the Tournalayer used 45 tons of concrete and one ton of reinforced steel. Special concrete mixing and pouring machinery was used at the casting site, and special cranes assembled the interior forms. For obvious reasons, this equipment has usually been rented, and not sold, by LeTourneau.

A number of projects have been built in the Southwest using the methods described above. In such a climate, it is not necessary to take many measures to improve the insulating properties of concrete, and for this reason, as well as the very important one that the Tournalayer requires a minimum of skilled on-site labor, it has been of considerable interest to builders in such parts of the world as South America and the Middle East. It has aroused interest also because of the surprising fact that it offers a good deal of diversity, being able to make very different structures by simple rearrangement of the forms, and even to cast two-story structures.

D. Honeycomb Core Sandwich Materials

Perhaps the most promising aspect of the various honeycomb core sandwich materials [12] is that, through their use, prefabrication of the house shell becomes very largely the production of one particular material. Designs embracing these new materials utilize the stressed skin principle so extensively that there is a bare minimum of frame assembly work to be done, either in factory or in field. There are still such problems as window and door openings, and joints between panels and at the floor and roof, but with the exception of a few systems of concrete construction, most of which involved but little prefabrication, the development of the sandwich materials represented the most direct attempt to change the building of the shell from a bits and pieces assembly job to an automatic continuous material manufacturing process. Such processes had already been developed for certain building products such as sheet metals and wallboards, but the manufacture by similar methods of a composite material that would serve at once as structure, insulation, enclosure, and finish still waits to be achieved. The honeycomb core materials were not the only ones using the sandwich principle. Cemesto, for instance, is a mass-produced composite material consisting of a cane fiber insulation board surfaced on both sides with a ⅛″ cement asbestos sheet, and combines good insulation and surface qualities. It has been used only as a curtain wall, however, not as a bearing wall. A related line of development has been pursued for a number of years by William B. Stout.

Of the various types of core materials, plastic-impregnated paper has thus far received the most attention.[13] It is possible that such paper cores may eventually be manufactured as separate materials to which can be bonded surfacings of metal, plywood, paper-overlaid veneer, or other types of laminates having the properties required for stressed skin panels. At the time of the survey there had been no mass production of these cores for use in housing, although processes had been developed for similar materials in other uses, floors in aircraft, for instance. A good deal of development work had been

[12] See "Physical Properties and Fabrication Details of Experimental Honeycomb-Core Sandwich House Panels," *HHFA Technical Paper,* no. 7 (February 1948).

[13] Other materials which have been tried include plastic-impregnated fabrics, foamed slag, foamed rubber, and glass.

done, however, and one factory was reported to be fully equipped for the production of house panels of this material.[14]

Because it has not yet been worth while for the paper manufacturers to produce a plastic-impregnated paper especially for the purpose, the production of the core on a small scale, for development work, began by treating a kraft paper with a phenolic resin solution. The purpose of this treatment was to enable the paper to retain its strength when exposed to moisture and to resist attack by decay or fungi.

Fabrication of the core from the resin-impregnated paper then could proceed by several different methods and could result in a number of different types of core. One of the simplest processes began by passing the paper, which was received from the mill in rolls, through a corrugating machine and then through an oven to cure the resin. After this the paper was cut into squares, or strips, and passed through a glue spreader which applied glue to the nodes of the corrugations. The sheets were then stacked in either of two ways: with the flutes of adjacent sheets at right angles to one another or with the flutes of adjacent sheets parallel and the nodes of adjacent sheets in contact with each other, depending on the balance desired between insulation and strength. The stacks were then put into a press, after which they were sliced into portions of the proper thickness for a panel core.

Another method for making the core omitted the corrugating operation. Sheets of plastic-impregnated and cured paper were striped with glue lines spaced at about ¼″ and were stacked and pressed together with the glue lines of adjacent sheets parallel to each other and staggered. After the glue had dried, the stack was simply expanded in the manner of a Christmas bell, and it was then ready to have surface skins bonded to it. There had also been some development work on automatic core-making machinery, but none of the methods in use at the time of the survey could produce in continuous strip.

[14] The following are known to have been interested at one time or another in honeycomb core sandwich materials:

(1) Acorn Houses, Inc.
(2) Consolidated Water Power and Paper Co.
(3) Chrysler Corp.
(4) Consolidated Vultee Aircraft Corporation
(5) Forest Products Laboratory
(6) Kimberly-Clark Corp.
(7) John D. Lincoln Furniture Co.
(8) St. Regis Paper Co.
(9) Southern California Homes, Inc.
(10) United States Plywood Corp.
(11) Utley-Lincoln System, Inc.

The first method described was considered by many to be slightly preferable from the viewpoint of production, because of its relative simplicity and of the avoidance of any heavy investment in machinery. It also afforded somewhat better insulative value.

Two types of equipment, roll and press, were used for bonding the skin to the core, both of which were still being developed. The Chrysler Cycleweld process utilized rolls and high-frequency induction heating to produce a quick bond between core and skin, both of which were preheated on their way to the machine. Should the skin material come in continuous sheet form and should some method be devised for making up cores continuously or as a continuous chain of blocks, this process offered the possibility of the automatically controlled manufacture of a standardized product—walls, floors, and roofs "by the mile." On the other hand, the use of a large hot press seemed somewhat more compatible with the production of panels having various openings, edge fittings, and other specialized features such as would be necessary at least in the production of walls. The firm which had most closely approached commercial production of houses made from this material was set up to use such a large hot platen press.

V. Some Particular Aspects of Production

Prefabrication plants had several characteristics in common, regardless of the materials with which they were working, and these are described briefly in the following section.

A. Factory Storage Facilities

One of the comments most frequently made by executives was that if they had another plant to design they would certainly increase the amount of space devoted to storage. At the time of the survey there were at least two important factors contributing to the inadequacy of storage facilities for raw materials. First, the building situation was

characterized by shortages, difficulties in procurement, and delays in shipping. This often made it necessary for factories to carry unbalanced inventories and to take materials as they could get them. Secondly, production was seldom stable for a variety of reasons—inability to obtain one or two items needed for the package, seasonal fluctuations which the distribution system had not been able to iron out, and, most important, the failure of the marketing arrangements to provide a steady flow of orders. In short, the materials-in-transit concept of mass production had not been realized except by a very few companies.

Storage space for manufactured goods was required for two principal reasons, to permit a relatively constant production volume with a fluctuating rate of sales and to allow time for certain curing processes. In the manufacture of plywood panels, for instance, recommended practice was to allow a period of at least a few days in which the glue could attain full strength and in which the water added to the wood by the glue could be distributed uniformly. Precast concrete units also required a curing period before they attained sufficient strength for use. Of the 84 companies whose storage practices could be ascertained, 40 stored panels according to type and made up packages as orders came in; 24 stored their finished goods as house packages; five stored them both ways, first according to type, then according to house package; and 15 indicated that they kept no finished inventory to speak of.

B. Plant Layout

Plant layout is an important aspect of production because it gives an indication of the stage to which manufacturing methods have advanced. Mass production involves two primary concepts: quantity and standardization. The extent to which these concepts are realized in prefabrication plants largely determines whether plant layout will more closely approach line production or repetitive station production.

Line production may be defined as a method of manufacture or an arrangement of work areas in which the material moves continuously and at a uniform rate past a series of work stations and through a sequence of balanced operations, thus progressing towards completion along a reasonably direct path. In repetitive station production, on the other hand, all the materials are brought to a number of work

stations at each of which one crew performs a complete sequence of operations.

Thus, line production is characterized by a thin stream of material which proceeds from the receiving department through fabrication, assembly, and finishing to shipping along one line, or at most a few; it involves a breakdown of operations into the simplest possible elements and an extensive division of labor. Its advantages are many: expensive high-volume production machinery can be effectively used; there is a reduction in materials handling; more efficient utilization of labor is made possible by greater specialization; supervision is facilitated because delays are quickly detected and workers are paced by the line; there is less congestion in the work areas; and the enforced study of operations before the line is set up frequently results in increased efficiency. Against these advantages must be balanced a number of limitations. A standardized output of reasonably large quantity is required if labor and machinery are to be utilized economically; a delay in the flow of materials to any point or in operations at that point may force workers further down the line to remain idle; and workers may be opposed to working on lines, especially if they are accustomed to craft jobs; even if they are not opposed their productivity and enjoyment of the work may be less.

For these and other reasons, many companies expressed a belief in the economy of repetitive station production at the time of the survey. In some cases their manufacturing process involved little standardization of either house or components, with many types of panels being produced, each at its own jig table. In other cases fluctuations in volume were severe, and more economical production could be achieved by minimizing the investment in tools and allowing the labor force to vary with volume—the number of similar work stations being increased or decreased as the occasion required. Occasionally the general scale on which production was carried out did not warrant investment in conveyers, high-speed equipment, and tools. These were some of the factors underlying the planning of repetitive station layouts, several of them in plants producing at relatively high volumes: The Green Lumber Company, Hamill and Jones, American Houses, and Pre-Bilt Homes Co., Inc.

It should be pointed out, however, that while these considerations may have been applicable to some companies making use of wood frame and plywood construction, the nature of the fabrication processes with other materials, notably metals, was such that it would generally not be feasible to establish a repetitive station layout.

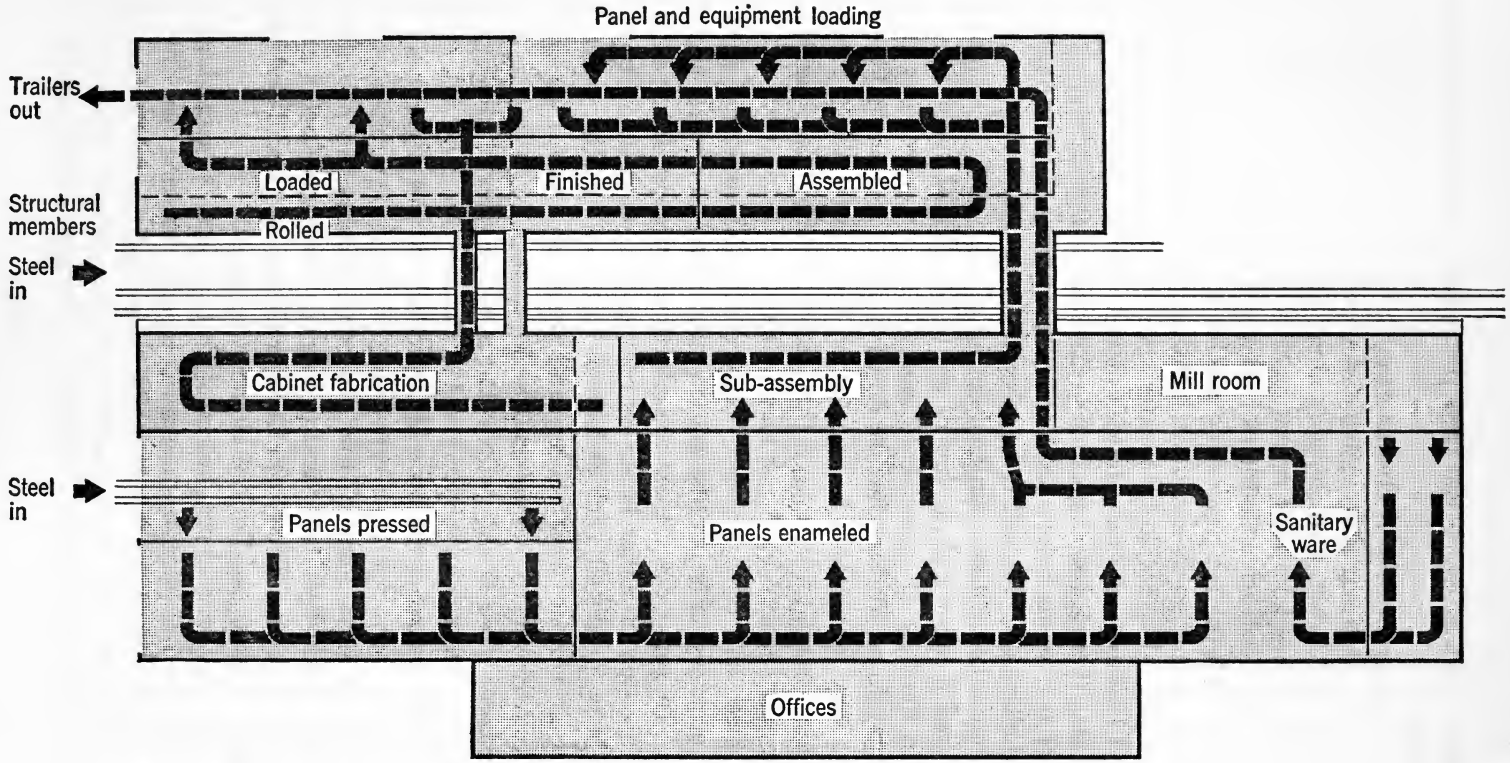


Figure 45. Lustron Plant Flow Diagram

Some 53 out of the 103 prefabrication plants whose layouts could be analyzed had more of the characteristics of line production than of repetitive station. At least 37 companies were using conveyer lines, and several were considering a type of layout in which jigs would move past a series of work stations, rather than having the material in process move down a line of jigs. Harnischfeger [15] was beginning to use this scheme, and some of Lustron's assembly operations were set up in a similar way (see Figure 45). Furthermore, many of the companies which had turned to line production systems had previously had several years' experience with less elaborate layouts more like the repetitive station plan, for instance, Crawford, Green's Ready-Built, Gunnison, Harnischfeger, National Homes, and Pease. Their preference for the line production process may have been a sign of some maturity in the industry and was certainly an indication that many prefabricators had done a good bit more than just move a traditional set of operations from the field into a factory.

C. Production Scheduling

Prefabrication factories were further distinguishable with respect to their methods of scheduling production. On the one hand, there were those plants which used what might be called a "job-lot" system of timing, producing only after a definite order had been placed for a specific job. On the other, there were those firms whose production was scheduled on a more or less "steady-flow" basis, and which manufactured standardized units somewhat in advance of specific orders, maintaining a finished inventory of varying size. The job-lot scheduling system was widely utilized by those firms which produced a variety of designs, sometimes even individualized designs. For example, Precision-Built could take almost any floor plan, modularize it, and produce it on what was essentially a line production set-up. American Houses was also producing on a job-lot basis, but with an assembly technique more like a repetitive station scheme, and with a good deal of precutting and preassembly of standard parts. This company's orders were usually for large projects, so that once a design entered production, the firm could get some of the benefits of a steady-flow basis. Another example of a compromise type of schedul-

[15] An important reason for the Harnischfeger scheme was to increase the capacity of a given size of plant.

ing was that offered by Better Living, Inc., which produced framing subassemblies and floor, ceiling, and roof panels ahead of orders and stocked them as standard parts, but which made up room-size wall panels of varying dimensions only as actually ordered. Perhaps the best examples of steady-flow scheduling were those plants which produced modular panels somewhat ahead of sales so that an order for a particular house could be filled from stock and shipped immediately, as did Gunnison and Green's Ready-Built. At the time of the survey, however, the overall demand was such and the materials shortages were so great that these distinctions were often rather academic.

It is obvious that, for optimum production efficiency, materials should be in continuous transit from receiving to shipping departments, and that there should be an order outstanding for each piece that comes off the line. This can probably best be realized if the house is standardized, or if the components of a number of different houses are all standardized. Not only does this facilitate efficient production, but the concept of interchangeability of packaged components is important also in shipping, for if a dealer is not ready to take a house on a certain day because of weather, financing difficulties or other delays, the same components, or almost all of them, can be used somewhere else. Advantageous as it might be, however, steady-flow production could not be carried on by prefabricators for more than a limited period. Daily and weekly production economies were achieved through steady-flow scheduling, but the leveling out of larger fluctuations arising from marketing difficulties, financing problems, and bad weather could not easily be managed, and virtually no firm was in a position to carry on full production in the face of seasonal changes in building. To stabilize plant operations completely while being subject to these and other disturbances in distribution would have required far more capital than was available in most of the prefabrication industry, and probably more capital than it would have been economical to tie up for the advantages gained, even if it had been available.

In making a broad comparison between the plants visited, it was found, as might well have been expected, that there was some correlation between line production and steady-flow timing, and between repetitive station production and job-lot timing. The correlation is not so strong as one might expect, and yet it does serve to bring out the fact that there are interrelationships among such factors as quantity, degree of standardization, extent of breakdown of operations, division of labor, rates of material flow and of processing, and the usefulness of specialized production equipment. It is because of the

interaction of all these factors that a prefabrication system becomes as much a matter of industrial design as it is of architecture.

Layout	*Scheduling*	*Number of Companies*
Line production	Steady flow	38
Repetitive station	Job lot	29
Repetitive station	Steady flow	21
Line production	Job lot	15

VI. Analysis

A. The Amount of Manufacture by the Prefabricator

An important fact in analyzing the contribution of the prefabricator is the generally small proportion of the house which he actually produces in his factory. This is a clue on the one hand to his inability to achieve radical economies thus far, and on the other hand an indication of some of the difficulties he faces in the field. There was, indeed, wide variation among prefabricators in the extent to which they carried prefabrication. This variation is a result of differences in design, local building codes, local labor and building practices, the size of projects, and other factors.[16] Even so, a general statistic will convey some useful information about the cost structure of the industry. The average house package offered by 53 companies f.o.b. factory represented 48% of the retail price of the erected house, ready for occupancy, but exclusive of land cost. An analysis by the Office of the Housing Expediter of cost breakdowns submitted by 12 applicants for guaranteed market contracts revealed a somewhat larger percentage, 58%.[17] Figures ranged from 37% to 77%, and in consideration of the inadequacies of data of this sort, it is necessary to generalize that the average prefabricator was selling a package representing roughly half the dollar value of the finished house, less lot.

[16] Chapter 7 contains discussion of what is and what is not prefabricated under various systems.

[17] This cost breakdown is reproduced in Table 3. The information is also summarized on p. 149 of *High Cost of Housing.*

Next, it may be asked what part of the value of the package is "created by" the prefabricator as a producer and what part is contributed by the materials used. Probably the most satisfactory measure of this is the "value added by manufacture," that is, the increase in the total value of the commodities passing through the prefabricator's plant as represented by the difference between the cost of the materials consumed and the value of the products made from them. The survey indicated that for the average prefabricator the value added by manufacture amounted to about 35% of the house package price. The figures of the Office of the Housing Expediter came to roughly 40%. Again, in both cases, there was a wide range in the data, from 25% to 45%, due largely to differences in design and in the relative amounts of jobbed materials and processed materials going into the package. As the package was composed more of materials which the prefabricator simply bought, stored, and packaged, and less of materials which he actually processed in his plant, the prefabricator became a synthesizer and distributor rather than a producer, and the lower was the percentage of value added by manufacture.

Noting that the house package represented about 50% of the value of the finished house and that only about 35% of the package was "created by" the prefabricator, we can deduce that his contribution, as measured by the value added in manufacture, is only about 18% of the retail price of the house. When we compare this figure with the percentage of value added by manufacture in several other industries, we see that it is quite small: automobiles, 32%; furniture, 49%; lumber and basic timber products, 56%; machine tools, 70%.[18] This puts the prefabricator in a difficult position for, supposing that by some means he is able to cut his production costs in half—no mean feat—he will have reduced the cost of the finished house by only 10% (setting the percentage of value added at an even 20%). In fact, his contribution is so small that his production position, from a cost point of view, might be termed precarious. Although this situation may not have been too well understood by some of the more enthusiastic proponents of prefabrication during recent years, it was pretty generally appreciated by members of the industry.

Prefabricators are attempting to do a job in the factory that has traditionally been done in the field. When that job is moved from the field to the factory, overhead zooms upward. The small builder has practically no

[18] Census of Manufacturers, 1939, Vol. II, Part 1, pp. 509, 549; Part 2, pp. 431, 522. Values cover the period from 1931–1939. The comparison is somewhat unfair because these figures represent per cent of *wholesale* price.

overhead by comparison. In the factory we have, or should have, low labor rates, but overhead compared to that in the field is multiplied many times. That means we must do the same job more cheaply in the factory after accounting for a greatly increased overhead. Of course, we should be able to furnish materials more cheaply than the builder can buy them himself, but it is also desirable that we do the work on the materials more cheaply than the builder can do it. Put it this way: *the value added to the materials by the manufacturer is a small part of the total value of a house. Since it is a small part of the total, the savings on this segment of building cost must be decisive and must be demonstrated.*[19]

The desire to increase their contribution to the total value of the house, and to achieve the potential economies therefrom, was a major factor in causing many prefabricators to manufacture items which were subsidiary to the main structure, doors, cabinets, closets, etc. There were other reasons, too: to assure a steady supply in a period of shortages; to obtain the exact dimensions and specifications necessary for a certain design; and to utilize scrap pieces, for instance by gluing them together to make counter tops for kitchen cabinets. There were, on the other hand, manufacturers who maintained that it was more economical to buy such items from specialty houses, or that it would soon be more economical to do so because of the production efficiency that went with such specialization. In any case, the following numbers of companies were found to be manufacturing various subsidiary items:

Item	*Number of Companies*
Window sash	38
Trim	37
Doors	36
Kitchen cabinets	31
Plumbing assemblies	27
Wardrobes, closets, or storagewalls	17
Sheet-metal ductwork	13
Flooring (softwood)	3

Whether through production or purchase there seemed to be a trend towards supplying a more and more completely prefabricated house. This was not a trend which could be positively ascertained, since the survey was, by its nature, a look at the industry at a definite time. Yet the expressed expectations and intentions of many prefabri-

[19] From a talk entitled "Uniform Cost Accounting for Prefabricators," by William A. Tucker, Statistician, PHMI, at 5th Annual PHMI Meeting, March 31, 1948. This statement points up production problems, but perhaps minimizes the savings possible in overall integration of the housebuilding process, from procurement to final financing and erection.

cators lay in this direction. The reasons given related primarily to the economies which they hoped to realize through greater efficiency in procuring various components and materials and in production, through less site wastage, fewer setbacks due to weather, and less time lost by having one crew wait for another to finish its work.

It was not demonstrated, nevertheless, that the greater the degree of prefabrication, the lower the costs; the optimum degree of prefabrication was not established. Certain designs were largely dependent on the use of factory processes, while others were quite as easily fabricated in the field as in the shop. In the latter case, a question such as whether roofs should be panelized or precut, or perhaps not furnished at all, was one which hinged to a great extent on conditions at the site: the cost of field labor relative to factory labor, the skill of crews available for erecting the house in the field, the conditions of weather and land at the site, the cost of supplementary materials in the field, the transportation costs from plant to site, the number of houses being erected in one group, etc.

For wood frame designs there seemed to be an inverse relationship between the amount of fabrication economically performed in the plant and the number of houses to be erected in one group. American Houses, for instance, was fabricating only about 40–45% of its structure in the factory, but seldom sold house packages for erection in groups of less than 100. The Byrne Organization's 1,200-unit Harundale project (not a wood frame design) utilized careful cost-accounting methods to divide the work between site and shop; roughly one-fifth of the total man-hours per house were performed in the shop, the balance at the site.[20] The abandonment by Kaiser Community Homes of the prefabrication of wall panels in favor of precutting [21] is a further indication of this point. Other large operative builders such as Levitt, Bohannon, and Ponty seemed to find that some combination of precutting the main structure and prefabricating minor components gave the most economical results, and much of the war experience with large projects pointed to similar conclusions. The major reason was, of course, that in such projects many aspects of mass production could be achieved without entailing the overhead and distribution expense that burdens the prefabricator. There could be mass purchasing, use of jigs and high-speed cutting equipment, and an extensive division of labor among crews that move from

[20] *High Cost of Housing*, p. 168. Actual figures given, 207 man-hours in the shop and 797 at the site, were proved low by later accounting. Final figures were not available.

[21] This change in pattern of operations occurred after the survey was completed.

house to house, rather than having the houses move past them on an assembly line.

On the other hand, single-house or small group erections did not offer these opportunities, and it was argued that for such projects much more fabrication should be done in an off-site factory where mass-production techniques could be used. Whereas one firm which precut and erected its own house reported that it cost $1,200 less per house to build in groups of 10 or more than to build a single house, the cost differential which could be obtained from erecting a highly prefabricated house, such as a sectional type, in groups rather than singly was probably quite small. Certainly, in such a case as the TVA sectional house, where shipping and field assembly accounted for only 12% of the total costs, or the British AIROH house, where these items were estimated to comprise only 9% of the total, the economies of large projects could not be too important.[22] This argument cannot be carried too far, however, for the costs of grading, installing utilities, and constructing the foundation could be appreciably lowered in large projects. And if, as in some sectional house systems, heavy equipment such as a boom crane was required at the site, further economies could be realized through large group projects. Finally, it goes without saying that the larger developments improved lots more cheaply. Notwithstanding these qualifications, it seemed a reasonable hypothesis in general that the larger the number of houses to be erected in one group, the less the optimum degree of prefabrication.

Probably as important a factor in governing the amount of prefabrication as any of the above was the existence of many problems of a "political" rather than a technical nature, including such practices as local purchasing to appease local distributors, and the elimination of certain items because of the wide diversity in codes. The solution of these problems will require much time and effort; undoubtedly the attention which they have recently received has been helpful. When consideration is given to this factor and to the steady, if slow, progress in materials and structure through research and development, there was evidence of a trend towards more complete prefabrication, at least of major components. This trend seemed most noticeable, and most logical, where the newest materials and structural systems were involved.

[22] "Total cost" here excludes cost of land, grading, utilities, and foundation. The last three of these items for the average AIROH house totaled twice as much as the shipping and site assembly costs. For TVA cost breakdown, see Table 5. For AIROH figures, see Table 6.

B. Production Volume and Production Costs

Before turning to an examination of actual production costs it would be useful to know how costs varied with volume and to what degree prefabricators were successful in achieving one of the prerequisites for mass-production economy: high volume.

The volume at which major production economies began to be possible was not easy to specify. It depended largely on the nature of the house, the materials of which it was made, and the extent to which it was composed of repetitive elements. Thus, one manufacturer of a panelized but otherwise quite conventional wood frame design reported that he would make no profit if he produced one house per day, $18,000 per month if he produced two houses per day, and $45,000 per month if he produced three houses per day. On the other hand, one of the manufacturers of stressed skin panel houses was operating with a break-even point of four to five houses per day. The break-even point for a venture such as Lustron was probably between 30 and 50 houses a day, compared with its capacity of 100 houses per day, on which figure its pattern of operations was predicated. Furthermore, it was difficult to untangle such factors as the importance of other manufacturing operations where prefabrication was only a subsidiary one. It was clear, for instance, that a lumber and millwork company which carried on a subsidiary prefabricating operation would have a different cost picture from that of a company whose sole work was prefabrication. The former might achieve economies through bulk purchasing of raw materials and through intensive utilization of production equipment simply because of the large-scale manufacture of millwork, and not at all because of its prefabrication volume, which might be quite insignificant by comparison.

In the light of such wide variations there was no single volume at which mass-production economies began. It is a fundamental characteristic of industrial production in general that as volume increases, up to a point, unit costs decrease. No company reported that it was operating in the range where increasing outputs would no longer yield decreasing unit costs. The question might better be put, what volume was necessary to attain an important share of the economies deriving from mass production?

Houston Ready-Cut felt that it did not begin to achieve maximum economies at less than 2,500 units per year. W. W. Rausch, then of

Anchorage Homes, said that he believed an annual production of at least 10,000 houses per year was necessary for full production economies with wood. C. W. Farrier, a former Technical Director of NHA who served as Housing Research Director for Gunnison, reported that "some of the prefabricators whom I have talked to indicate that the volume of houses that they will have to turn out in the plant in order to have sufficient ordering power to get reduced prices on materials amounts to somewhere between 20 and 25 houses a day" [23] (5,000–6,250 units a year). A British writer, D. Dex Harrison, said, "It seems likely that the specialized designs will require a minimum of 5–10,000 [units per year] before the economy of mass production is achieved in the house as a whole and before variations on the one design can be contemplated." [24]

These estimates, all but one of which are explicitly based on wood as a material, average about 5,000. No company, in either 1946 or 1947, produced this many houses; the largest annual volumes reported were between 1,500 and 2,500.[25]

As for the industry as a whole, it was operating at somewhat less than half its estimated capacity in 1946 and 1947. Between October 1946 and June 1947, 87 plants were visited which were actually in production. Of these, 27 gave no estimate of capacity, and the remaining 60 reported that they were producing at an average of 38% of stated capacity.[26] This, of course, must be evaluated with the seasonal pattern of building in mind. A winter slump is customary, even in prefabrication. In 1946 the industry produced 37,200 houses, and in 1947, 37,400.[27] At an average package price of $3,500, this would mean a gross dollar volume of about $130,000,000. The 1947 total, however, represents the output of considerably fewer firms, so

[23] *Proceedings, American-Soviet Building Conference,* p. 50.

[24] Harrison, "An Outline of Prefabrication," in *Tomorrow's Houses,* p. 132.

[25] 1947: American Houses, 1,600; National Homes, 2,500; Kaiser Community Homes, 2,500.

[26] Breakdown of 60 companies according to reported capacity:

Over 200 houses per month	5
100–199	9
50–99	13
25–49	11
Less than 25	22
	60

[27] 1946 total by the Office of the Housing Expediter, 1947 total by PHMI, PHMI News Release, May 3, 1948.

that average production per firm rose substantially.[28] Even so, at the beginning of 1948 PHMI estimated the industry's existing capacity at 120,000 houses per year,[29] so that, based on this figure, the production for the previous year was at less than one-third of capacity.[30] It is therefore safe to generalize that the industry as a whole was not utilizing its plant facilities to the optimum extent and that there were potential production economies which had not been achieved.

C. Productivity

One way of measuring the potential effectiveness of prefabrication in reducing costs is to find out how much it increases the productivity of labor or, put another way, decreases the number of man-hours required to build a house. For this purpose two statistics can be used: the number of man-hours of direct factory labor per house, and the number of man-hours of direct site labor per house. These should be qualified, however, by differences in the size and quality of the house, by differences in what is included in the prefabricator's package, and by differences in the amount of the package which the prefabricator procures rather than produces himself.

For 29 producers of wood houses there were required an average of 226 man-hours in the factory. Figures ranged from 100 to over 600. Other studies of prefabricators working in wood have yielded results of the same order of magnitude. The 1947 PHMI survey of 40 member companies gave an average of 268 factory man-hours per house, and a study by the Bureau of Labor Statistics [31] of 14 prefabricated war housing projects found an average of 242.

At the site, 26 companies were found to require an average of 238 man-hours to erect and complete the house, exclusive of subcontracted work such as grading, foundation, heating, wiring, plumbing, and sheet-metal work. PHMI found in its 1947 survey that an average of 182 man-hours was consumed in erecting the house and an average

[28] OHE figures for 1946 include shipments by 198 producers. The 1947 figures are based on shipments of approximately 80 companies.

[29] Statement of Harry H. Steidle, Manager, PHMI, before the Joint Committee of Congress on Housing, January 14, 1948.

[30] Actual production in 1948 was 30,000 units (PHMI News Release, June 4, 1949).

[31] Alexander C. Findlay, "Construction of Prefabricated and Conventional War Housing Projects," *Monthly Labor Review*, 63 (November 1946), 723, 727. See below, pp. 342–4.

of 276 in finishing it, making a total site time, exclusive of work on the lot and foundation, of 458 man-hours per house. The BLS study, based on large projects where many economies at the site were possible, found an average of 440 site man-hours per house, but this figure included work on grading, utilities, and foundation. All the above figures were for wood houses of various designs, except that no sectional types were included. There were some well-publicized demonstrations in which a house was erected in less than half a day by a few men, but when these were examined more closely it could be seen that a good bit of preparatory work had been done in improving the site, building the foundation, and, often, in having special pieces of equipment ready to do their special jobs. With the sectional house, the time required for erection was at a minimum. The Reliance house, for instance, was completely erected in a demonstration during a snowstorm in less than 20 man-hours.[32] The Prenco and TVA houses generally were erected, complete with all connections made, in one day or less, using a crew of six to eight men. The AIROH house, a British sectional type of which more than 69,000 were built since the war, required less than 50 man-hours [33] to erect, whereas other prefabricated houses built under the British Temporary Housing Program which arrived at the site as collections of panels, cabinets, subassemblies, and loose material required an average of 300–400 man-hours [34] of site labor. Again, these figures do not include the work of preparing the site and foundation and of installing utilities. A cost analysis of the AIROH house, for instance, shows that these three items may total over four times as much in cost as the erection itself.[35]

If allowance is made for these differences in basis of figuring among the companies, then for the "typical" 24′ × 32′ house of panelized wood construction roughly 250 man-hours were required at the factory and 450 at the site (not including grading, utilities, and foundation). It would be interesting to compare these figures with comparable figures for convential construction, but it is difficult to obtain productivity data for conventional building which would permit a fair comparative analysis. Not only should such data be classified according to the size and quality of the house, but also according to the number of houses built in any one project, the conditions of

[32] Near Philadelphia, Winter 1948.

[33] Unpublished paper by Carroll A. Towne, Prefabrication Advisor, HHFA, May 1948, in the files of the Bemis Foundation.

[34] *Loc. cit.*

[35] *Loc. cit.*

weather, materials supply, and so forth. Estimates range from 1,000 to 2,500 man-hours as the labor time required in building one house by conventional methods, but the exact basis of these estimates is not clear. In the absence of results of controlled experiments, it will have to suffice to use what would seem a reliable figure and a fair one for purposes of comparison: the estimate developed by the Small Homes Council of the University of Illinois in its time-study analysis of the construction of the "industry-engineered house."[36] This was a two-bedroom, single-story, 768 sq. ft. dwelling with basement. The total requirement by conventional methods averaged 2,091 man-hours,[37] and, according to the report, "Records indicate that savings up to 20% of total labor can be made by the use of engineered construction methods and organized operations at the site."[38] Figures included all work from excavation for the basement to finishing details. They were, furthermore, based on the construction of one house at a time.

When housing is built in large group projects, however, productivity comparisons are apt to yield quite different results. Probably the best study of this sort was one made by the Bureau of Labor Statistics based on 24 war housing projects, two-thirds of which were prefabricated.[39] It was found that the average saving in total man-hours at the prefabricated projects was only about 8% (p. 343). All the projects studied used wood as their basic material, but the prefabricated group was further classified into three different types: stressed skin, frame panel, and incomplete prefabrication (the last subgroup included two frame assembly and two frame panel with conventional floors and roofs). Man-hour requirements for these three classifications were found to differ significantly: for the first they were nearly one-quarter less than for conventional construction, for the second about 2% less, and for the third about one-sixth more. The comparisons were for corresponding operations—the customary site work at the conventional projects and the site work, plus factory work, plus related operations such as transportation at the prefabricated projects. As the study was careful to point out, however, the data used were insufficient for general comparisons between prefabricated and conventional construction. For one thing there were differences in weather, in

[36] *Research Report on Construction Methods.*

[37] Of this total, excavation, footings, foundation, basement, floor, floor joist and subfloor accounted for 257 man-hours.

[38] *Research Report on Construction Methods,* p. 16.

[39] Findlay, *op. cit.,* pp. 721–32.

the "natural" efficiency of labor,[40] and in materials supply conditions in different regions. Furthermore, the data applied to housing built in large group projects so that, in effect, the word "conventional" had a rather special meaning. Lastly, it would be unfair to judge present prefabrication by the wartime product.

Unit Man-hour Requirements on War Housing Projects (by type of construction)

Type of Construction	Man-hours		Requirements as a Percentage of Conventional Requirements		
	Per Dwelling Unit	Per 1,000 Gross Sq. Ft.	Per Dwelling Unit	Per 1,000 Gross Sq. Ft.	Composite
Conventional	917.2	998.8	100.0	100.0	100.0
Prefabricated	682.1	978.3	74.4	97.9	92.7
Stressed skin	564.3	798.7	61.5	80.0	75.9
Standard panel [1]	716.3	1,041.7	78.1	104.3	98.5
Incomplete [2]	877.0	1,236.0	95.6	123.7	117.3

[1] Frame panel according to our classification.

[2] Includes two frame assembly and two frame panel with conventional floor and roof.

Source: Alexander C. Findlay, "Construction of Prefabricated and Conventional War Housing Projects," *Monthly Labor Review*, 63 (November 1946), 721–32.

In spite of all these variables, however, mention should be made of some of the conclusions of this study:

(1) Of the total man-hours required for site work, from a fifth to three-fifths could be transferred from the site, to be carried on in the prefabricating plants and in related operations such as transportation. In no case, however, was the site work reduced to a negligible figure, the lowest being 261 man-hours.

(2) As for skills, the prefabricated projects required a larger percentage of laborers' and foremen's man-hours than conventional operations. However, it was found that the prefabricated and conventional operations were not so dissimilar in percentage distribution of skilled workers and foremen by trades.

[40] For instance, differences in standards and in the "natural" efficiency of labor made the data biased in favor of stressed skin and against incompletely prefabricated houses.

(3) The comparatively few instances in which non-structural work, such as plumbing and electrical work, was performed in the prefabricating plants demonstrated that a net man-hour saving could be expected from such plant operations only under certain circumstances: when there were a minimum number of connections to be made between panels; when work could be concentrated in a small portion of the house, for instance within one or two adjoining panels; and when excessive protection or care was not required to prevent damage during transport.

D. Production Costs

Turning now to a consideration of costs, probably the single criterion by which prefabrication has most often been judged, the final production cost of a prefabricated house should, ideally, be compared with that of a conventionally built house of the same size and quality in the same location. Further, a determination by accurate accounting of the optimum degree of prefabrication, qualified according to the type of market, the design, the number of houses being built in one group, and many other factors, would be desirable. But the main interest of the consumer is the price of the house, and price involves many factors in addition to production costs factors such as market size and location, dealer organization, transportation, and financing, which are covered in the next chapter.

Unfortunately, reliable cost breakdowns are difficult to develop. For one thing, manufacturers were understandably reluctant to release the information. For another, cost-accounting systems were not uniform, the same item being counted in a number of ways by different prefabricators. (Recently there had been an effort, led by PHMI, to standardize cost-accounting practices so that prefabricators could compare cost figures and learn from each other.) And third, companies varied greatly in the extent to which they acted as jobbers, in the amount of production which they did themselves, and in the completeness of their package. For these and other reasons outlined below, such cost breakdowns as can be presented in a publication of this sort are of somewhat limited value.

1. Cost Figures Submitted to the Office of the Housing Expediter

Tables 2 and 3 summarize data submitted to the Office of the Housing Expediter during late 1946 and the first half of 1947. This information should be interpreted with the following facts in mind: the sample was a very small one; the figures do not reflect today's prices; and the data were really estimates of cost made by firms which, for the most part, had done little or no previous work in prefabrication—therefore some of the figures might better be regarded as declarations of intent than as records of performance. A digest of these figures appears in *High Cost of Housing* along with a commentary written chiefly by the staff of the Housing and Home Finance Agency. We quote:

> The direct factory labor costs range from a low of 1.13 percent to a high of 14.10 percent. The low percentage is found in a plant which subcontracts virtually all of its fabrication, and therefore a fair median percentage would be closer to 12 percent than the average of 7.48 percent shown in table 2.
>
> . . . It is obvious that prospects of securing cost reductions through elimination of direct and indirect labor in plants are definitely limited. For example, cutting the direct factory labor cost in half would reduce the total cost of the erected house by 3 to 6 percent. Reduction of field labor costs, which range from a low at 7.81 percent to a high of 26.17 percent, perhaps holds more promise.
>
> On the other hand, the direct materials cost in the house package is, in every case, the highest single factory cost item. In most cases, this is true in the field as well. The prospect of savings here, both by development of designs which eliminate unnecessary material, and by reductions in unit materials prices through elimination of wholesale mark-ups are substantial.
>
> Indirect and administrative costs generally represent such small percentages as to offer little promise of cost reduction. It should be noted that allowances for factory sales expense are abnormally low in every case. Informed judgment on this subject has concluded that a factory sales allowance of 5 percent is essential to successful merchandising in this field.
>
> Considered either separately or combined, the factory and field allowances for profit in this tabulation cannot be regarded as excessive. . . . Actually, the average field profit of 8.84 percent is somewhat below that which is customary in the field of conventional building.[41]

It may be interesting to note, by way of comparison, that the evidence presented to the Joint Committee on Housing of the 80th Congress [42] indicated that, for conventional residential construction, labor

[41] *High Cost of Housing*, p. 151.

[42] *High Cost of Housing*, pp. 76–9. Sources quoted: Housing and Home Finance Agency, Bureau of Labor Statistics, New York City Housing Authority, The Econometric Institute, Inc., New York. Much of the testimony is conflicting.

Table 2

Summary of Unit Costs of Prefabrication Price Ranges

Element of Total Cost	Total			Plywood		
	From	To	Average	From	To	Average
Package, total	2,269.13	5,794.57	3,460.67	2,747.26	5,794.57	3,799.57
Erection, total	1,150.00	3,824.00	2,448.27	1,150.00	2,657.83	1,828.99
Total cost, less land	4,468.19	7,702.42	5,908.94	4,468.19	7,518.57	5,628.56
Package						
Direct material	1,243.98	3,081.00	2,110.37	1,785.07	3,081.00	2,344.41
Direct labor	63.60	1,060.29	451.08	163.44	1,060.29	700.48
Indirect labor	65.36	604.39	183.82	111.63	185.38	143.27
Other indirect	116.30	577.18	331.42	284.30	577.18	431.01
Administration	29.94	197.00	97.30	29.94	52.28	39.88
Sales expense	37.57	258.98	151.38	152.40	258.98	200.41
Profit	226.91	579.46	354.70	256.03	579.46	399.11
Erection						
Direct material	232.00	1,905.00	841.85	232.00	831.99	401.44
Direct labor	422.00	1,471.44	820.35	422.00	986.84	693.67
Freight and delivery	45.00	375.00	163.63	45.00	260.00	128.75
Indirect labor	.....	.....	.....	.....	.....	.....
Other indirect	31.50	125.00	86.03	50.00	100.00	77.86
Administration	.....	.....	.....	.....	.....	.....
Sales expense	.....	.....	.....	.....	.....	.....
Profit	250.00	807.00	526.41	370.00	613.00	491.00
Total, package and erection						
Direct material	2,017.07	3,696.96	2,970.43	2,017.07	3,448.00	2,709.01
Direct labor	947.44	1,647.29	1,253.48	947.44	1,647.29	1,262.28
Total direct costs	3,062.10	5,250.20	4,228.09	3,062.10	5,095.29	3,908.04
Freight and delivery	45.00	375.00	162.63	45.00	260.00	128.75
Indirect labor	65.36	604.39	183.82	111.63	185.38	143.27
Other indirect	50.00	659.18	327.78	50.00	659.18	361.50
Administration	29.94	197.00	97.30	29.94	52.28	39.88
Sales expense	37.57	259.98	151.38	152.40	259.98	200.41
Profit	450.00	1,192.46	865.55	450.00	1,192.46	842.13

Source: Office of the Housing Expediter figures.

Table 2 (Continued)

Summary of Unit Costs of Prefabrication Price Ranges

Element of Total Cost	Wood			Metal		
	From	To	Average	From	To	Average
Package, total	2,269.13	3,351.61	2,665.49	2,823.60	4,716.36	3,872.63
Erection, total	2,579.00	3,824.00	3,163.58	1,835.57	3,159.00	2,580.76
Total cost, less land	5,150.74	6,839.61	5,829.08	5,622.64	7,702.42	6,453.39
Package						
Direct material	1,243.98	2,108.91	1,621.56	2,015.14	3,067.98	2,462.89
Direct labor	272.27	401.50	334.33	63.60	500.00	341.77
Indirect labor	65.36	65.36	65.36[1]	72.00	604.39	304.41
Other indirect	116.30	116.30	116.30[1]	126.82	534.70	270.34
Administration	82.00	142.56	112.28	117.45	197.00	147.23
Sales expense	90.77	123.50	107.14	37.57	172.96	124.47
Profit	226.91	335.16	266.55	306.40	471.63	407.19
Erection						
Direct material	1,047.00	1,905.00	1,380.08	345.60	1,406.00	915.34
Direct labor	692.00	1,230.00	908.00	719.00	1,471.44	942.23
Freight and delivery	60.00	375.00	233.33	65.00	290.00	132.00
Indirect labor	.....	.....	.....	.....	.....	.....
Other indirect	75.00	125.00	108.33	31.50	75.00	60.50
Administration	.....	.....	.....	.....	.....	.....
Sales expense	.....	.....	.....	.....	.....	.....
Profit	465.00	646.00	533.83	250.00	807.00	560.00
Total, package and erection						
Direct material	2,666.47	3,507.91	3,001.64	2,415.60	3,696.96	3,249.65
Direct labor	964.27	1,613.25	1,242.33	1,058.60	1,535.04	1,259.20
Total direct costs	3,630.74	4,808.61	4,243.98	3,950.64	5,250.20	4,657.12
Freight and delivery	60.00	375.00	233.33	65.00	290.00	132.00
Indirect labor	65.36	65.36	65.36[1]	72.00	604.39	304.41
Other indirect	191.30	191.30	191.30[1]	126.82	609.70	305.84
Administration	82.00	142.56	112.28	117.45	197.00	147.23
Sales expense	90.77	123.50	107.14	37.57	172.96	124.47
Profit	722.17	981.16	800.38	721.63	1,189.00	967.19

[1] Information on one firm only; therefore not an average figure.
Source: Office of the Housing Expediter figures.

Table 3

Breakdown of Cost to Consumer of Erected House without Lot

Element of Total Cost	Total (%)			Plywood (%)		
	From	To	Average	From	To	Average
Package, total	37.24	77.07	58.34	55.39	77.07	66.93
Erection, total	22.93	62.76	41.66	22.93	44.61	33.07
Total cost, less land	100.00	100.00	100.00	100.00	100.00	100.00
Package						
Direct material	20.42	46.83	35.20	39.83	41.82	40.79
Direct labor	1.13	14.10	7.48	3.35	14.10	11.87
Indirect labor	1.07	7.84	2.89	2.05	3.65	2.55
Other indirect	1.89	7.68	5.20	6.36	7.68	7.14
Administration	0.64	2.56	1.53	0.64	0.69	0.67
Sales expense	0.56	3.44	2.46	3.20	3.44	3.37
Profit	3.72	7.71	5.92	5.39	7.71	6.93
Erection						
Direct material	4.88	31.26	14.21	4.88	13.97	7.22
Direct labor	7.81	26.17	14.20	7.81	17.15	12.63
Freight and delivery	0.90	5.48	2.78	0.90	5.47	2.37
Indirect labor	....	....	....	....	....	....
Other indirect	0.48	2.43	1.49	1.09	1.82	1.38
Administration	....	....	....	....	....	....
Sales expense	....	....	....	....	....	....
Profit	3.82	14.36	8.84	8.15	9.23	8.53
Total, package and erection						
Direct material	42.96	58.05	50.00	44.89	54.57	47.39
Direct labor	14.58	27.30	21.22	19.43	23.38	21.99
Total direct costs	61.19	78.21	71.72	67.77	74.00	70.20
Freight and delivery	0.90	5.48	2.78	0.90	5.47	2.37
Indirect labor	1.07	7.84	2.89	2.05	3.65	2.53
Other indirect	1.05	8.77	5.23	1.05	8.77	6.10
Administration	0.64	2.56	1.53	0.64	0.69	0.67
Sales expense	0.56	3.44	2.46	3.20	3.44	3.37
Profit	9.23	21.15	14.40	9.23	15.86	14.46

Source: Office of the Housing Expediter figures.

Table 3 (Continued)

Breakdown of Cost to Consumer of Erected House without Lot

Element of Total Cost	Wood (%)			Metal (%)		
	From	To	Average	From	To	Average
Package, total	37.24	50.13	45.84	50.21	71.98	59.59
Erection, total	49.67	62.76	54.16	28.02	49.79	40.41
Total cost, less land	100.00	100.00	100.00	100.00	100.00	100.00
Package						
Direct material	20.42	31.45	27.90	28.36	46.83	38.37
Direct labor	5.19	7.00	5.74	1.13	7.63	5.17
Indirect labor	1.07	1.07	1.07[1]	1.07	7.84	4.17
Other indirect	1.91	1.91	1.91[1]	1.89	6.94	3.70
Administration	1.43	2.34	1.89	1.79	2.56	2.20
Sales expense	1.49	2.15	1.92	0.56	2.64	1.88
Profit	3.72	5.02	4.58	5.40	7.20	6.31
Erection						
Direct material	20.25	31.26	23.60	6.15	22.56	14.14
Direct labor	13.38	20.19	15.53	9.33	26.17	15.35
Freight and delivery	0.98	5.48	4.01	0.97	3.77	1.98
Indirect labor	....	....	....	....	....	....
Other indirect	1.23	2.43	1.89	0.48	1.33	0.93
Administration	....	....	....	....	....	....
Sales expense	....	....	....	....	....	....
Profit	9.02	9.45	9.15	3.82	14.36	8.83
Total, package and erection						
Direct material	49.85	52.71	51.50	42.96	58.05	51.01
Direct labor	18.72	26.48	21.27	14.58	27.30	20.17
Total direct costs	70.30	78.16	72.77	61.19	78.21	72.59
Freight and delivery	0.98	5.48	4.01	0.97	3.77	1.98
Indirect labor	1.07	1.07	1.07[1]	1.07	7.84	4.17
Other indirect	3.14	3.14	3.14[1]	1.89	7.92	4.19
Administration	1.43	2.34	1.89	1.79	2.56	2.20
Sales expense	1.49	2.15	1.82	0.56	2.64	1.88
Profit	12.82	14.35	13.73	11.02	21.15	15.14

[1] Information on one firm only; therefore not an average figure.
Source: Office of the Housing Expediter figures.

costs range from 35% to 45% of final price, less lot. This was a substantially greater proportion than that shown by Table 3, in which total direct labor costs accounted for 14–27% of the final price, less lot, and total indirect labor costs accounted for 1–8%. The lower proportion of labor costs in prefabrication has been explained not only by greater productivity, but also by lower hourly wage rates stemming from the lower skill requirements, better working conditions, and steadier employment.

In considering the percentage allocated to sales expense, it should be remembered that the data represented mostly new firms which did not have established distribution systems. An unfortunately large number of prefabricators during this period thought that, because of the acute housing shortage, all that had to be done was to get the production line moving—that somehow the process of getting the houses from the end of the line to the customer's lot, financed and ready for occupancy, was not a problem. Experience has proved otherwise, and if similar estimates were to be submitted today, they would probably include a much more substantial item to cover the costs of establishing an organization able continuously to sell, finance, erect, and service houses as they are produced. Once such an organization was established and growing at a small but steady rate, however, its percentage cost might well be reduced.

Another item that deserves attention is the sum of indirect and administrative costs. It may be true that these, as the above quotation points out, "represent such small percentages as to offer little promise of cost reduction." But to stop here would be to overlook at least two important points. For one thing, while these costs may be a small percentage of the total at high volumes, they may skyrocket as volumes fall. During the past few years overhead costs have been the downfall of more than a few newly established prefabricators who required some time to smooth out their operations and who, by the time they had overcome the problems of marketing, found that their working capital had been consumed in such expenses.

More important is the relationship between the overhead encountered when the building process is moved into a factory and the savings in labor cost thus achieved. Clearly, from the production standpoint, if the additional indirect expenses outweigh the savings in direct costs, it is uneconomical to shift an operation from the field to a plant removed from the site. This point has been very well summarized by Robert W. McLaughlin, a veteran prefabricator:

> Criticize the so-called construction industry as you will, it has demonstrated its ability to operate in the field at an extremely low overhead.

Exclusive of insurance and social security charges, overhead on construction labor is of the nature of 5–10%. In any factory, on the other hand, overhead on direct labor will vary from 100% to 300% or even more. My own experience with wood fabrication was that factory overhead ran something over 100%. That is factory overhead only, without administration or sales expense. I am told that a plant of average mechanization, such as a vacuum cleaner plant, will have an overhead ratio to direct labor of about 150%, and that in more highly mechanized straight line production the rate will be of the nature of 200% or even higher. What does this mean with respect to the factory processing of wood? Assume a field labor operation costing $100. With 10% overhead the operation performed in the field will appear on the cost sheet at $110. Along comes the prefabrication enthusiast who assures you that he can save 40% of the direct labor cost by doing it in the factory—that he can do the $100 operation in the factory for $60 worth of labor. 40% is quite a saving. But immediately he has to add at least 100% factory overhead, and his true cost becomes at least $120 as against a field cost of $110. Also we have to think about additional transportation and handling. It is apparent that removal of a labor operation from the field can be justified only if the direct labor saving is really great—of the nature of 75% or 80%. This substantiates our earlier statement that if we are to change the locale of the process at all we have to change the overall process radically. We also categorically state that the nature of wood does not present enough opportunity for mechanization to warrant a shift in the process from field to large, central factories.[43]

This telling comment by one who has spent more than 15 years prefabricating in wood, metal, and other materials is not to be brushed lightly aside. McLaughlin's estimate that factory overhead costs amount to about 100% of direct labor costs is substantiated by the figures in Table 4. In this breakdown it can be seen that direct factory labor and factory overhead are roughly equal. In very few circumstances have prefabricators yet achieved savings in direct labor of 75–80%, and, in the light of the above reasoning, this may offer at least a partial explanation for the somewhat disappointing results of prefabrication in cutting the cost of building to date.

2. Budget Cost Figures of a Large Producer of Stressed Skin Plywood Houses

Table 4 presents the percentage breakdown of unit costs for the package only. The figures indicate allocations of cost expected in order to break even on an annual production of 1,500 units, with the

[43] Talk delivered at Massachusetts Institute of Technology, February 26, 1948.

indicated net income serving merely as a safety margin. At least 10% profit would be required for a continuing operation. Production of more than 1,500 units would lower percentages for plant expenses and for sales, general, and administrative expenses. As these were lowered through increased volume, the gross profit and net income would increase accordingly. The house in question was of stressed skin plywood construction and was being produced in one of the best-equipped plants in the industry.

Table 4

Budget Cost Figures Based on 1,500 Houses per Year

A Large Manufacturer of Stressed Skin Plywood Houses [1] (January 1, 1948)

Item	*Per Cent*
Total house package (f.o.b.)	100.00
Direct materials	
Processed materials	52.91
Jobbed materials	24.75
Total	77.66
Total labor	
Direct manufacturing	3.82
Rework and repair	0.36
Materials handling and shipping	1.96
Service and maintenance	0.72
Wage premiums	0.06
Total	6.92
Margin above materials and labor	14.43
Indirect plant expense (materials and service)	2.24
Plant overhead and administrative expense	3.89
Total plant cost	91.70
Gross profit	8.30
Sales, general and administrative expense	
Selling expense	2.02
General administrative expense	2.63
Total	4.65
Operating profit	3.65
Other income and deductions (net)	1.48
Grand total all costs	94.87
Net income before taxes	5.13

[1] These figures are for a 24′ × 28′ house. Package price, f.o.b., $4,100. The average price of this house, erected but less lot, would be about $7,000.

Table 5

Cost Breakdown for TVA Sectional House (1943) [1]

Item	*Per Cent*	*Dollars per House*
Gross sales	100.00	2,673
Materials	43.96	1,175
Labor	18.71	500
Plant burden		
Rent	0.94	25
Heat	0.56	15
Light	0.56	15
Power	0.56	15
Insurance	0.56	15
Maintenance	0.56	15
Supervision	2.24	60
Cost of manufactured goods	68.65	1,835
Manufacturing profit	31.35	838
Expenses		
Selling	2.43	65
Shipping		
Loading	0.56	15
Weather protection	0.56	15
Trucking	5.16	138
Permits	0.37	10
Unloading	1.31	35
Field assembly		
Labor and materials	2.24	60
Supervision and overhead	1.88	50
Advertising	0.37	10
Administration	2.62	70
Social security and taxes (except income)	1.68	45
Total expenses	19.18	513
Operating profit or profit before depreciation	12.17	325
Depreciation	1.88	50
Net profit before federal taxes	10.29	275
Federal taxes	5.61	150
Balance	4.68	125
Interest on invested capital	0.94	25
Net profit on sales	3.74	100

[1] Erected house less furniture and equipment (range, refrigerator, water heater, and space heater), and excluding land, foundation, and site utilities. Two-bedroom house, 24′ × 24′, three sections.

Source: Estimates by TVA which were reconciled with the experience of several firms having contracts for production of these houses.

On Table 4 it will be noted that factory labor costs were a very small part of the total package cost and that materials represented by far the biggest item. This is partly due to the fact that the materials as they were received had been largely cut and milled to size, and the factory operations were chiefly assembly and finishing. It can also be seen that factory overhead was somewhat greater than direct labor costs, but it is necessary to consider that in this case some of the factory overhead was expended on the storage and handling of finished materials and equipments which were included in the package sent to the dealer and should, for this reason, have been allocated to the dealer's cost sheets rather than to those for the manufacturing operation. The sales expense represented only the prefabricator's costs in this breakdown and did not include expenditures by dealers.

Table 6

Cost Breakdown for AIROH House

British Temporary Housing Program (1947 Estimates)

Item	*Per Cent*	*Pounds* (£)
Production		
Materials, fixtures, and fittings	51.8	847
Factory fabrication and assembly	17.0	278
Other production costs	2.7	44
Factory plant and equipment	2.6	43
Transport		
Expenditure on vehicles, spares, and repairs	1.5	25
Haulage	2.6	43
Grading, utilities, and foundation	14.6	238
Erection	3.3	53
Contingencies	1.7	28
Overhead costs	2.2	36
Total	100.0	£1,635
Less net residual value of productive assets		25
		£1,610

Table 5 is a cost breakdown for a TVA sectional house. The house measured 24′ × 24′, had two bedrooms, and arrived at the site in three sections. The figures are for 1943 and are based on estimates by TVA which were reconciled with the experience of several firms having contracts for the production of these houses. The principal point of interest here is the extent to which the manufacture of the house had been transferred to the factory. The motive behind this was probably more the desire to reduce site labor requirements than it was economy. Site labor had to be kept to a minimum because of

the wartime shortage of construction labor, because of the desire to reduce the number of people and the confusion at the site, and because of security reasons, since about 5,000 of these sectional houses were built at Oak Ridge, Tenn., and Hanford, Wash., two of the atomic energy production centers. The relatively large shipping costs, about 8%, were due to the fact that transporting the sectional house involved careful handling of a finished product, which included much empty space, over relatively large distances in some cases.

Table 6 is a breakdown for the British AIROH house, a sectional aluminum structure which was produced in large quantities in aircraft plants after the war. The figures are estimated rather than official, but they serve as an informative basis of comparison with the figures for the sectional wood TVA house. It will be noted at once that, because this house is sponsored by the government, advertising and selling are not items of cost.

Part II.

Chapter 10

MARKETING

I. Introduction

The marketing aspects of any industry are properly defined as including "all business activities involved in the flow of goods and services from physical production to consumption." [1] For the prefabrication industry, this includes the determination of markets, prices, channels of distribution, and methods of sale; and the procedures used in financing, site selection, transportation, erection, and servicing. Many of these subjects have been discussed in earlier chapters, for marketing considerations have an obvious influence on decisions regarding production, procurement, design, and management, although the extent of this influence has not always been recognized in the industry.

In the period immediately following the war, the breadth and importance of marketing problems were not generally appreciated. Procurement and production problems were far more pressing, and, with the demand for housing running at the highest level in recent history, it was easy to visualize an eager line of customers, checkbooks in hand, waiting to claim the houses as they came from the plant. Few of the companies in the field had had any experience selling prefabricated houses; many had never sold houses of any sort. Furthermore the industry was young, the war had been won, and it was not hard to dismiss as gloomy conservatism the warnings of those who had learned about marketing the hard way during the depression.

During the period of the survey, the marketing lessons were gradually being learned. Government contracts terminated, and bidding for large projects began to mean cutting costs and profits to the bone. High hopes engendered in the days of the Veterans' Emergency Housing Program began to dissolve, and slowly the real bottleneck was located—at the end of the assembly line. Foster Gunnison, who had always placed marketing first in order of importance, had warned the industry in 1944:

> It is obvious that orders must flow into the plant, each day, at the same continuous rate the houses flow off the conveyors. . . . The investment in a mass-production plant is so great that it will only pay-out by keeping the plant going to capacity every day. To provide a continuous flow of orders, therefore, becomes the most important problem of all. Thus, upon the

[1] Harold H. Maynard and Theodore N. Beckman, *Principles of Marketing* (4th ed., New York: Ronald Press, 1946), p. 3.

method of distribution and sales used, depends the ultimate success or failure of the industry as a whole and each company within it.[2]

Nearly ten years earlier, John Burchard had been even more precise:

> The focus of efforts so far has been on the redesign of the structure of parts of the house, often very ingeniously. But the trouble with these efforts has been that they run squarely against the stone wall of the amount of capital required to bring an old un-mass-produced product into mass production almost over night, and the economies proposed are available only if the mass production is achieved. A sounder approach, it would seem to me, might be made by regarding the problem at the outset as one of marketing. After marketing success with a semi-orthodox product, the economies and advantages of new structures might be incorporated.[3]

Marketing patterns were being formed at the time of the survey, in many cases very elementary, in a few cases more advanced, and the rest of this chapter is devoted to describing these patterns.

II. Markets

A. Market Areas

The prefabricator's choice of market areas was greatly influenced by the type of product he wished to offer and by the manner in which he wished to offer it. If he decided to make a complete and distinctive house, bearing his trade name, he would usually plan to sell it either in large urban centers in direct competition with the operative builder, or in rural areas where there were fewer problems with codes, labor unions, and competitors. If he preferred to make a factory package, to be put into the final house without identification of the maker, he would usually plan to sell it either to large speculative builders in the cities or to small contractors and individuals spread over a wide area. The preference of the prefabricators with reference to a few simple classifications of market areas, and the reasons which they gave for their choice, are summarized below.

[2] Foster Gunnison, "The Economics of Mass-Distribution and Mass-Sales of Prefabricated Homes," *Prefabricated Homes*, 2 (February 1944), 23.

[3] Burchard, "Prefabricated Housing and Its Marketing Problems," p. 154.

1. Metropolitan Areas

An almost exclusive interest in the metropolitan areas, roughly defined as those having populations of 100,000 and upwards, was expressed by 25 companies. On statistical grounds alone this would have been a good choice, since census figures indicate a continuing trend in the United States for the population to move into such areas (and, within them, to move outwards from the built-up centers of cities). Despite the fact that the metropolitan areas had a somewhat smaller proportion of single-family houses than the rest of the country, they probably contained almost as large a total number of such houses. While the built-up centers were characterized by high land costs and stringent building restrictions, even there certain prefabricators felt they might have advantages to offer. For example, the fireproof house built by Fabcrete of America, Inc., could be erected in districts from which wood frame houses were excluded in the interests of fire prevention.

Most of these 25 companies, however, were interested in the suburban fringe, which offered such attractive features as wide selection of building land at suitable price relatively close to a concentrated demand, relatively broad range of demand, convenience of transportation, likelihood of many vacant lots already provided with streets and utilities, and the best general prospects for large projects, whether to be built for sale or for rental investment. Particularly for those who produced unconventional houses, the concentration within metropolitan areas of young business and professional families and of families of relatively high incomes was a decided advantage.

2. Smaller Urban Areas

More desirable to the average prefabricator, despite the advantages of metropolitan areas, were the smaller urban areas, where the populations ranged from 2,500 (the smallest urban area in census computations) to 100,000. In all, 52 companies expressed a preference for such market areas, with the major interest in the more populous areas within this range. The prefabricators mentioned several special advantages in such areas. They were generally considered to have lower wage scales and other operating costs; this made them low-cost plant locations, and low cost meant broad marketing advantages. While the overall demand was not so large as in a metropolitan area,

it was nevertheless adequate in view of the scale of operations of the average prefabricator, as was the available supply of building sites. The costs of improving the land were not so great in smaller cities, where standards were usually lower, development less intensive, and wages and costs lower. Taxes almost always were lower in smaller cities than in metropolitan centers, although metropolitan suburbs might compete on this score. It was usually considered easier to establish friendly relations with trade unions, with the various municipal departments, with bankers, and with potential customers in the smaller cities. The advantages of speed and efficiency offered by a dealer in prefabricated houses were found to be relatively more apparent in the smaller cities where large-scale builders were rare and therefore the dealer had a relatively better risk in the use of his capital. And, finally, the aggregate of orders flowing in from a diversified selection of smaller cities where these favorable conditions might be found was considered to yield a steadier rate of production than would be the case with orders flowing from any one metropolitan area.

In the very small urban areas these arguments lost some of their force. The tendency of the population to move towards the cities meant that demand for houses was often less in the smaller towns; the inhabitants were noticeably more conservative in their tastes and in their manner of doing business; and because the prefabrication plant was itself likely to be located near a somewhat larger city, transportation costs were often higher.

3. Rural Non-Farm Areas

A preference for the rural non-farm area, defined as including communities of less than 2,500 population which contain little land in farm uses, was expressed by 22 companies. From census figures this would seem to be by far the best market for prefabricators, since almost as many total single-family dwelling units are being erected in rural non-farm areas as in urban areas.[4] There was a very real feeling on the part of many of the prefabricators that this constituted their best market. John Richardson, whose experience lies in financing and sales, told those attending the December 1947 PHMI Winter Meeting that in his opinion the "market is 75% in rural areas and small

[4] *Construction*, U. S. Bureau of Labor Statistics (January 1948), p. 4.

towns," and C. W. Farrier, formerly head of the Technical Division of NHA and more recently research director for Gunnison Homes, earlier had said almost precisely the same thing.[5] The advantages of such areas lay in the possibility of erecting a good-quality house with very reduced site labor requirements on a site far removed from the nearest skilled conventional builder. Frequently houses designed for these areas would have less costly finish and equipment, although the prefabricator might well attempt to include within his package as much as possible of the necessary materials and equipment. Frequently, also, the houses were to be designed for minimum site improvement (probably without a basement), and for erection processes involving as little special equipment and skilled labor as possible. The design of the house itself could be highly standardized since it would not be frequently reproduced within the area. And perhaps the largest single factor favoring the rural non-farm areas was the fact that conventional builders in such areas were at the very end of the normal materials distribution channels. This gave the prefabricator, with his greater buying power and speed, a very decided advantage. Admittedly, the establishment of suitable sales methods and distribution forces to reach so scattered a market offered a difficult problem, and it was one which no prefabricator had fully solved at the time of the survey, although many were keenly interested in the possibilities offered by so broad and stable a potential market.

4. Rural Areas

Eleven companies indicated a preference for rural areas as a market for their houses, such areas being defined as those devoted primarily to farming. Most of the companies featured houses which could be erected by the farmer himself, who represented one of the few groups in the consumer population generally capable of doing an efficient job of erection. Many of these farm cottages are highly standardized in design, the usual theories about the need of apparent variation being dispensed with in view of the wide scattering of purchasers. Frequently companies operating in rural areas also prefabricated farm utility buildings; indeed many entered upon the prefabrication of houses from that field, for example, Pre-Fab Industries Corporation and Economy Portable Housing Company.

[5] C. W. Farrier, "Prefabrication in Post-War Housebuilding," *Prefabricated Homes*, 2 (February 1944), 11.

A specialized form of the rural market was the market for recreational cottages, sought after by an increasing number of prefabricators after the lifting of the restrictions of the Veterans' Emergency Housing Program. Hodgson, probably the oldest continuing prefabricator in the business, had been making a large share of its sales in this market since 1892. Here designs commonly varied widely with demand, and houses could be greatly simplified by the temporary and usually warm-weather nature of their intended use. Structurally, the houses were generally panelized into sections capable of being easily manhandled, and the erection system was usually simple enough to permit the use of unskilled labor on rather rough and isolated sites.

B. Special Market Types

Prefabricators had varying preferences with regard to channels of distribution; in the selection of these channels, they were often also making a choice between two broad types of market: that in which distinctive houses, given a sort of "brand name" by advertising and promotional efforts, were sold to the public; and that in which specialized house packages, varying according to the circumstances involved in the order, were sold to the dealer or builder who offered them to the public without announcement of the identity of the fabricator of the basic package. Of the former, Lustron was a good example, and of the latter, American Houses. In addition to this basic distinction in market approach, several special types of market deserve further discussion.

1. Industrial Markets

At least 15 companies concentrated a major part of their efforts on selling large groups of houses to industries building for their employees. This was a natural outgrowth of the war period, during which sales had been made to government agencies in large quantities, and of the period of boom construction immediately following the war, when new housing was needed near new plant facilities. It was easy for the prefabricators to shift over from large government orders to large industrial orders. American Houses sold units to the

builders of several such projects, among them one for 250 families in Manville, N. J., to house employees of a Johns-Manville plant. U. S. Homes developed special low-cost designs adapted to the needs of southward-migrating textile companies. Nygaard Builders, Inc., developed for a Pittsburgh contractor a unit designed for housing in coal-mining communities. With the decline in postwar industrial expansion and the general leveling-off of business activity, this market was showing signs of shrinking, but during the period of the survey it still was a significant factor in the plans of these prefabricators.

2. Export Markets

Among the companies interviewed, six indicated that they had shipped houses outside the continental limits of the United States, and seven more said that they were making definite plans in that direction. Other companies expressed interest, but had no plans at that time. Aside from the lend-lease program,[6] however, actual sales in foreign markets had been small, and such sales as there were came about as the result of special circumstances rather than any serious demand on the part of foreign consumers.[7] This was, of course, partly the result of the dollar shortages in most of the potential consumer countries, but partly also it reflected the difficulties and costs inherent in purchasing houses in the United States and shipping them abroad for erection and use under what often were very unfamiliar conditions. Companies seriously interested in the export market soon realized that special models, involving a considerable degree of redesign and the changing of dies and jigs, would be required, and that in most cases the redesign would have to be in the direction of simplification.

Transportation costs, when added to the high costs of production in the United States, constituted a serious difficulty. Unless extra handling and shipping costs were to be incurred, furthermore, units would have to be designed so as to permit their being broken down for shipment into relatively light and small packages.

For a time, during the worst of the materials shortages, government quotas were a further limitation on the export business. Quotas under the Second Decontrol Act, for instance, lumped prefabricated wooden

[6] Chapter 2, p. 60.

[7] Office of International Inquiries, HHFA, in an interview June 4, 1948.

houses with other wood mill products, and the unit limits were set as follows:

Year	*Quota*
1946	Closed. Each applicant examined individually.
1947	1,150
1948	3,440

However, such were the general difficulties that even these limited quotas were never filled. For example, during 1948 the quota was 3,440 houses, export licenses were issued for only 1,697, and only 330 were actually shipped abroad. These quotas were more recently entirely lifted, and it would have been possible to develop a good export business under certain conditions if more foreign countries had favorable dollar balances. As it was, the new country of Israel was nearly the only one able to devote dollars to housing, and Israel could not afford to spend its dollars on prefabricated houses designed and equipped for living patterns in the United States.

More likely to be shipped abroad have been machinery, materials, techniques, and skilled technicians. Six of the companies interviewed had exported their "pattern of operations" in whole or in part. This was particularly true of the sponsors of systems for the production of concrete houses. Wallace Neff, for example, reported for Airform Construction a Mexican licensee building schools in Mexico City and houses in Acapulco, a Brazilian licensee with houses under construction, and contracts or negotiations for contracts under way in Venezuela, South Africa, India, Egypt, Morocco, Spain, and Portugal.[8] Others also were involved in this way: Precision-Built Homes had a licensee in Canada and was considering arrangements for others in South America; Soulé Steel had developed a special house for the Hawaiian market, only the steel parts of which it planned to export.

It seemed likely at the time of the survey that the major purchasers of actual houses exported from the country were likely to continue to be United States companies operating abroad. For example, in 1947, all the 275 wood prefabricated houses exported had such destinations: 180 went to a United States business firm in the Dominican Republic, 40 to the Saudi Arabia Oil Company, and 55 to other identifiable commercial customers.

[8] Interview in Los Angeles, Calif., April 16, 1948.

III. Pricing Policies

Some honest confusion has usually attended any discussion of the selling price of prefabricated homes, for prefabricators offered many different kinds of prices. The lowest possible quotation was for a house package f.o.b. factory, but some quoted the cost of the house package plus transportation to the site. More commonly it was the erected price, less the cost of the land, although in a few cases the price included the land upon which the house was erected. In nearly all cases, some extra features were included in the price, such as built-in furniture, completely installed bathrooms, or kitchen appliances.

The pricing structure can conveniently be examined in terms of the experiences of 12 companies that were studied in 1947 by the Flanders Committee.[9] Cost data from the report of that Committee were given in detail in the chapter on production; selected data are reproduced here, with the prices of all the companies averaged together to give a representative picture. Using the total cost of the erected house, less cost of land, as 100%, the following relationships were significant:

Average house package	$3,460.67	58.34%
Average cost of erecting the house	2,448.27	41.66%
Total cost, less land	$5,908.94	100.00%

Looking further into the erection costs, it is found that $162.63, or 2.78%, was made up of freight and delivery costs. A combined profit was taken on the package and erection of $865.55, or 14.40% of the selling price. However, $350.70, or 5.92% of the selling price, represented profit attached to the house package, and thus went to the manufacturer.

Obviously, the price to the ultimate consumer was far more than just the house package cost. That, nevertheless, represented a feasible starting point for an examination of prices during the survey conducted by the Bemis Foundation. In the winter and spring of 1946–1947, 54 companies offered house packages at an average price of $4.02 per square foot. The average erected price of these houses, usually as quoted by them, was $8.45 per square foot, exclusive of

[9] *High Cost of Housing*, p. 150.

the cost of land, and the average size was 762 sq. ft. The average selling price which resulted, $6,439, was probably lower than the typical selling price for the industry, because many of the 54 companies surveyed tended to have lower than average prices, and geographic variations in costs and in quality standards made a difference. The period studied was one of advancing prices, so that figures more recent than these would be considerably higher for comparable houses.

Further information on selling prices is furnished by a PHMI survey of its membership made in 1947. The median price for prefabricated houses was then found to be $7,000, exclusive of land, with prices ranging from $5,100 to $8,000. The most common size of house was 24′ × 32′, or 768 sq. ft.

By way of comparison, the average construction cost per unit of all single-family dwelling units started in the country was $5,525 in 1946, $6,750 in 1947, and $7,850 in 1948.[10] It should be emphasized that these figures, while including an allowance for builder's profit, do not include the cost of land; they represent only construction costs and not selling prices.

In general the price policy of a house manufacturer seems to have been determined by applying to his production costs an average markup selected to yield a reasonable profit for him. There was very little tendency on the part of the manufacturer to charge a price out of line with a fair return; the realization of the need for mass sales in order to maintain steady production seems to have served as a curb on his desire for immediate profits.

The price policy of dealers generally was a somewhat different matter. Dealers followed no single pattern, but a large number were inclined to take full advantage of the seller's market then prevailing, with little thought to future sales volume. During the period when price control was in effect, the OPA allowed a 10% dealer's markup on the cost of the house package. *Prefabricated Homes* magazine, stating the case for a higher markup, estimated that overhead expenses would amount to 7% of the selling price.[11] If a 7–10% net profit to the dealer were added to this, the resulting markup would be around 15%. Those companies which attempted to limit the dealer's profit usually allowed a markup of 15–20% of the sales price. Most franchises, however, gave the dealer the authority to set his own selling price; in most cases they had to, if for no other reason than varia-

[10] *Housing Statistics*, Housing and Home Finance Agency (May 1949), p. 4. Bureau of Labor Statistics figures.

[11] *Prefabricated Homes*, 6 (May 1946), 9.

tion in local land and improvement costs and wage rates. Many companies felt that better control of dealer prices in the future was essential to the industry, since one of the purposes of prefabrication was to provide the ultimate consumer with housing as good as or better than conventionally built structures, at a lower price.

The nature of the competition offered by conventional builders and other prefabricators determined to some degree the dealer's price policy, especially when dealers were located in areas where competition for the housing customer was becoming more severe. In particular, those dealers handling a fairly conventional house seemed to follow the price leadership of the operative builders in the area.

An exception to the general price averages was found in the case of 14 companies which concentrated on the higher price and more or less custom-design market, and commonly made use of modular panels or job-lot order modular component production systems. Sometimes the theory of such prefabricators, as presented by George Fred Keck, designer of Green's Ready-Built solar house, was to build for a quality market, relying on the fact that the factory can put on better finish and detailing than can be reproduced by a local building contractor at anything like comparable cost. A greater value, rather than a lower delivered cost, was the object, and it was hoped that, when this market was established and production costs cut, still more equipment and better value would be added instead of reducing prices for the consumer. Presumably, such houses would be particularly well designed to appeal to the income group which might ordinarily hope to have a very small house hand-tailored by an architect. With this quality market established, such a company might then consider bringing out a lower-priced model for a broader market, relying on the advertising appeal gained by its more expensive models.

On the other hand, a few companies were interested in producing austere shelter in the very low price ranges. For example, the Texas Housing Co. was selling its "Homette," a 16′ × 16′ plywood cabin, for $463.24, knocked down, early in 1947 (see Figure 44). The Wingfoot house, an expandable trailer with an area of 256 sq. ft., was being sold for as little as $3,000, ready for occupancy. Somewhat above this level, many prefabricators were starting to manufacture houses of standard size and equipment priced at $6,000 or less, erected, but excluding the price of the land. These structures had no basements, but standards of design, material, and construction were at least as good as those of similarly priced conventional houses. In 1948 National Homes Corporation brought out a two-bedroom house to sell for $2,089 f.o.b. the plant. With added costs of erection, wir-

ing, plumbing, etc., the two-bedroom model sold complete with lot for only $5,750, and could be purchased with a $300 down payment and monthly payments of $34.87. There was also a three-bedroom model priced with lot at $6,150 (see Figure 46).

Each model had a living room, a bath, a utility room, and a kitchen equipped with built-in cabinets, counter sink, and a laundry tray. Included with the house were an oil heater in the living room and an automatic water heater in the utility room. Plywood was used for the exterior finish, and inside walls were of waterproof, crackproof, room-size Upson board, used in natural finish, painted, or papered. The houses were erected on an insulated concrete floor with no basement and with no doors on the bedroom closets.[12]

After the initiation of the Economy House Program by the Housing and Home Finance Agency in cooperation with the building industry, most of the other companies announced special low-price models (see Figure 47). One, for example, designed by General Industries, Inc., to sell in the $6,000 bracket, was described by PHMI as follows:

> This economy home is a . . . one story model with two bedrooms, living room with dining area, kitchen, bath and a utility room, with additional storage room in the attic space. It is 24′ 3″ square, of stressed-skin plywood construction and is erected on a concrete slab. The inside walls are finished with wall paper or may be painted. . . . The buyer is offered several choices of exterior finish.
>
> Approved by the FHA for mortgage insurance, the houses are being financed under the new provision of the Housing Act of 1948 authorizing government-insured 95% mortgages on owner-occupant homes where such loans do not exceed $6,000.[13]

On the whole, however, it is fair to say that the prefabricated housing industry was only beginning to produce houses at a low cost for the mass market. Indeed, many prefabricators did not feel it should try to do so. One writer stated even before the postwar rise in prices that new houses should be priced from $6,000 to $8,000 rather than from $2,000 to $4,000, because the effective buying power resided in the seven or eight million families who represented the upper 20–

[12] National Homes estimated that 90% of the 25 houses per day produced throughout most of 1949 were these "thrift homes." Many features of equipment and finish have been added to recent models without increase in price.

[13] PHMI *Washington News Letter,* September 24, 1948, p. 3. By the time of the PHMI Fall Meeting at Winnipeg, October 1949, practically all member companies had come out with "economy" or "thrift" homes, and such homes represented 75–80% of total production in several cases.

25% of the income group.[14] And the $6,000 house of 1946 would cost close to $8,000 in 1948. Many outside the field felt that undue concentration on cost was producing houses of dangerously low space standards.

A few shared the feeling, best expressed by Carl Strandlund of Lustron, that it could not be expected that a family in the low-income group would be happy to invest all its resources in what was loudly proclaimed as a bare minimum house; it would prefer to pay a little more and get some extras—some genuine "quality" features—that would give a real pride of ownership. This feeling led Strandlund to invest money in top-notch architectural services for the overall improvement of the Lustron house in future models, and it also was behind the production, in 1950, of a three-bedroom model containing 1,209 sq. ft., and of garages, for one or two cars, which could be connected to the houses by breezeways.

On the other hand, the market pressure was such that Lustron, too, was prepared just before its failure to bring out an economy line. The Lustron Newport homes took full advantage of standard parts, running the regular roof trusses across the long dimension of the house to avoid the production of new structural members. There was to be a two-bedroom model containing 713 sq. ft. and a three-bedroom model containing 961 sq. ft. at prices competitive with the economy lines which made up almost the entire output of Lustron's competitors.

Another point of view was expressed by William K. Wittausch:

> Even though families move in order to improve their housing conditions, they need by no means move into new houses as evidenced by many millions of families who today live in houses which were not newly built for them but which are better than the houses they left. That is why the housing needs of millions of families, especially in the low-income group, do not necessarily represent a vast potential market for new, low-price, mass-produced houses.
>
> . . . Whether new or old, the quality of housing a family is able to occupy depends almost exclusively on its income. . . . it is only natural that the higher income families move into newer and more desirable houses first, with the families that cannot afford the pleasure of moving into a fresh, new house moving into the older and less attractive existing dwellings left by those who move out. New prefabricated houses like other new houses automatically command the same premium for freshness regardless of the price group in which they are offered. It would appear, therefore, to be more advantageous to prefabrication if the current em-

[14] Neal MacGiehan, "The House for the Mass Market," *Prefabricated Homes*, 5 (February 1945), 16–7.

phasis on producing low-cost houses rather than on putting higher value into houses relative to other new houses were to be reversed.[15]

Other prefabricators have been frank to state that the industry cannot produce new homes for the lowest-income group,[16] and that it should recognize the need of public housing for that group and the related possibility of a firm government housing policy to which prefabricators might adjust intelligent plans for operation under settled conditions over a long period.[17]

It is not the province of this discussion to attempt to find a method of meeting the need for really low-cost housing for the low-income groups. The survey indicated that as yet the prefabricated housing industry had not come up with the solution to this problem. But the problem was recognized, and efforts were being made by most prefabricators to lower costs. In the back of their minds seemed to be the hope of capturing the mass market with a house that cost no more than present secondhand houses, and yet was superior to them in most respects.

IV. Channels of Distribution

The pattern of handling goods between production and consumption, the channel of distribution, is determined by the system of handling and storing the components, the method chosen for moving the

[15] William K. Wittausch, "Marketing Prefabricated Houses," *Harvard Business Review*, XXVI (November 1948), 696–7.

[16] It should be added that several prefabricators believed, with Fred Gentieu of Plainfield Lumber & Supply Co., that they could reach the lower price ranges only in units other than single-family detached houses, that is, in row house or apartment units.

[17] While the industry has been officially opposed to individual public housing bills in the past, such views as this have been expressed by some of its most thoughtful members. In his address to the PHMI membership in December 1947, John C. Taylor, Jr., President, American Houses, Inc., said: "The people in this country are going to be adequately housed, and if private industry does not supply this housing, it is going to be supplied through Government subsidy. . . . The majority of you do not like subsidized housing any more than I do, but yet, if we are really true to ourselves and will bring our innermost convictions to the surface, we know that that statement is true."

goods at low cost, and the middlemen selected. No single system of distributing houses was common to all prefabricators, and several companies employed more than one channel.

A. Factory Direct to Consumer

From factory to consumer is the most direct method of distribution. In some cases manufacturers employing this channel made the erection of the house the consumer's responsibility, while in others the manufacturer himself took care of the erection.

1. Erection by Purchaser

Only one company sold all its houses for erection by the purchaser himself, but 19 companies sold part of their output for such erection. The simplicity of this distribution scheme appealed most often to the newer companies, especially those on the West Coast. However, while it is true that such a scheme was simple, it often involved the drawback of a specialized or limited market. Financing requirements, and the small number of customers willing to be responsible for erecting a full-size house, were the chief limiting factors. The FHA was reluctant to approve loans based on purchaser erection, and so this scheme usually was limited to companies offering non-FHA minimal units. Allied Building Credits was willing for a while to grant loans at high interest rates on such unpredictable risks, but this specialized financing firm soon became inactive in this field.

Immediately after World War II a large number of such units were produced as prefabricated garages. These garages, usually two-car size, were purchased by veterans in desperate need of housing. Nicoll and Co. sold 20′ × 24′ panelized cottage shells for $792. The John L. Hudson Co. produced as many as 80 garages a day, probably 50% of them used as dwellings.

While only a small percentage of the total housing market was willing to take the responsibility for erection in return for potential savings in cost, it seemed likely that there would always be some who would prefer this method. These purchasers liked the convenience of buying most of the materials for a house in one package, and were glad of the chance to reduce cash outlay by contributing their own

labor. Most of these purchasers were farmers, veterans, and building tradesmen, often operating within the framework of a cooperative. Some, however, like the purchasers of vacation cottages, were interested more in the convenience of getting delivery of a unit of known quality at a remote site, and in shortening construction time, and they were not likely to realize substantial cost savings.

Within the industry, it was generally considered risky to sell units direct to private owners for erection, and there was a growing sentiment that the prefabricator should assume the responsibility for seeing that the agent of erection performed the building operation in a satisfactory manner. Unless the house were so designed that erection became nearly as simple as connecting up a trailer, many prefabricators felt that savings inherent in good organization of site work might well be lost by purchaser erection. One prefabricator stated:

> The prefabricator who will stay in business will furnish a complete house, key in door, at a fixed price, and will be responsible for erection and finishing. The days of shanty jobs are over; the days of shell building are drawing to a close.[18]

In two different patterns, however, this channel of distribution was well established. The precut house, as produced by Aladdin and many others,[19] typically was distributed in this manner, and had been for 40 years. Indeed, Aladdin had tried a system of dealer-erectors some 12 years before the survey and had decided that the direct mail-order business, with individuals acting as their own building contractors, mostly in rural non-farm areas, was better suited to its purposes.

On the other hand, factory sales organizations frequently sold large groups of houses to a contractor, a municipality, or an equity investor. This middleman then went on to erect or to make the arrangements for erection by a contractor. Dealers were ordinarily not so well able to handle such sales, and some companies reserved the right even in exclusive dealer franchises to make sales of this sort them-

[18] C. F. Dally, President, Prefabricated Products Co., Inc., interviewed January 21, 1947.

[19] Sears, Roebuck and Co., which had sold precut houses from 1911 through 1942, brought out its Homart house in 1947. This was designed as a ready-to-erect house, partially precut, partially prefabricated, and partially of random-length materials to be cut to fit in the field. Sales were made through mail-order catalogues in Philadelphia, Boston, Chicago, and Kansas City (mostly to rural customers) and through the company's retail stores (mostly to customers living in nearby urban areas).

selves. At least 20 companies made part of their sales, and seven made all of them, in this way. American Houses was a good example of a company with a skilled central sales staff on the lookout for large project business; and the producers of precast concrete houses, for example, Vacuum Concrete, almost had to sell to large projects because their system of construction only then became economical. Most prefabricators, however, felt that distribution of this sort tended to be spasmodic and made it difficult to achieve the steady and predictable flow of production which they needed for greatest efficiency throughout the whole pattern of operations.

2. Erection by Manufacturer

Twenty-seven companies sold all their houses directly to the consumer and then erected the unit for him, while 30 additional companies handled part of their distribution in this way.

Ordinarily, distribution of this type was localized, with erection in the immediate areas surrounding the factory. It was found not profitable to send erection crews several hundred miles in order to erect one house or a small group of houses,[20] and labor unions tended to look with disfavor upon the arrival in the community of erection crews who were not members of the union local.

An important trend during this period of boom housing was the entrance into the prefabrication field of many large lumber dealers, who preferred to do this work themselves rather than continue to finance and supply builders as had been done before the war. Of the companies interviewed, six were lumber companies which decided to prefabricate and erect their own production. There undoubtedly were many other lumber dealers not included in this survey who prefabricated and erected houses on a local scale.

A more dramatic performance was the erection by factory crews of large site projects. Maximum economies could be obtained through a combination of centralized factory production with mass erection on a well-organized schedule on a large tract of land in the vicinity

[20] At least part of the reason for the failure of Anchorage Homes lay in its attempt to market its entire output (goal: 16 houses per day) direct to purchasers and to erect the houses above foundation with its own erection crews, who often commuted to and from scattered sites several hundreds of miles from the plant and were always hard to supervise.

of the plant.[21] Well-publicized examples of the combination of plant and site organization were the Byrne Organization and Kaiser Community Homes, where whole neighborhoods were involved and site location and planning became an obviously important factor in the success or failure.

A few companies put up their own houses in group projects before sales had been made to the ultimate purchasers. One reason for this was to insure steady production at the plant; this channel of distribution sometimes became, therefore, an adjunct to the more orthodox methods of sales. If the prefabricator had not sold as many house packages as were necessary to maintain a steady production rate, he would build a group on speculation. Hamill and Jones had 100 such houses under erection when interviewed. The California Prefab Corp. was putting out four houses a day for its own erection, but expected to sell only about two houses a week in response to orders from outside customers. Naturally, operations of this sort depended upon a continuing demand for housing in the price range offered, and they were found only in areas of great housing shortage.

Where houses were largely plant fabricated, as were the Prenco, Prefabricated Products, and Acorn houses, companies expressed a preference for carrying out a good part of the erection of nearby houses themselves, feeling that the combination of familiarity with their product and ability to shorten an already brief site labor requirement would be to their benefit.

B. Factory to Dealer to Consumer

Most prefabricators considered a middleman between the factory and the consumer a distributive advantage. The middlemen chosen were usually independent dealers whose job was to relieve the manufacturer of most of the marketing task, and to make prefabricated houses readily available to more people than could the manufacturer himself.

Certainly, in the eyes of the prefabricator, the principal function of dealers was to enlarge the market for his houses. The prefabricator

[21] Perhaps the clearest, although hardly a typical, example was that of the Parsons Construction Company, in Canada, which set up a demountable wood fabricating plant at each final project site, complete with movable tracks on which to roll finished panels to the section of the site in which the proper part of the erection process was in progress.

was limited in his ability to cover intensively what he regarded as his market area, but strategically located dealers could be on the spot all the time. By combining the orders from all these dealers the prefabricator could maintain steady production and concentrate his efforts on improving factory techniques.

Another advantage of the independent dealer was his familiarity with the local market. He was better able to know when a member of the community might become an active prospect for a house, and, in addition, his community tended to regard him as "one of them" and sales resistance therefore was likely to be less. He was also likely to be of great assistance to the purchaser in dealing with local building codes, tax regulations, finance problems, and site selection. Furthermore, he provided the prefabricator with much-needed financial aid. When the prefabricator delivered a house package, he was paid by the dealer. Thus, the manufacturer had less money tied up in the distribution process, and could devote more of his working capital to production purposes.

There were many different types of dealers, whose function with regard to the erection of their houses varied widely; they might themselves undertake the erection, or it might be done by the producer or even by the purchaser.

1. Erection by Manufacturer

Department stores occasionally were used as dealers for prefabricated houses. In such cases the house, a section of it, or a large-scale model of it was erected in the store, thus offering to the store's large clientele the opportunity of a detailed personal inspection with a minimum of effort. A sales representative was almost always present to describe the features of the house, arrange the sale, assist in financing, and perhaps suggest tie-in package sales through the store for furnishing the house. The factory delivered the house and erected it on the site. Precision-Built Homes planned to sell in this way, utilizing a "Precision Builder" who operated within a 50-mile radius, erecting all houses sold by the store in that area.

Only a few members of the industry believed that department stores were likely to become important dealers in houses. Most felt that the high unit value and low turnover rate of houses were not in character with most other items for sale in such stores, and that customer

buying motives would not be likely to lead them there to buy houses. Furthermore, it was pointed out that the many facilitating and follow-up activities connected with the sale of a house would be unduly burdensome for high-volume fast-turnover department stores to assume. In short, prefabricators tended to feel that the most valuable service the department store could offer would be to display the house to a large number of people, and to design related furniture and furnishing package sales which would ease the effort and expense of furnishing the house. Thus, Adirondack Log Cabin and Anchorage Homes, among others, made use of department stores only to display their house models; the store did not enter into the sales transaction.

Use was made by 24 companies of general dealers in prefabricated homes, with the understanding that the company would perform the erection of all houses sold by these dealers. By and large, the prefabricators felt that more sales were made through these dealers than through department stores, since their primary business was to sell houses and they would be able to seek out prospective customers more actively and to pay more careful attention to their needs.

In some cases the general dealers also provided, or arranged for, the land on which the houses were to be erected by factory crews. The Brice Realty Company, acting as an agent for Prenco, on one occasion sold both a group of 230 houses and the land on which Prenco was to place them. Of the companies using general dealers, seven distributed almost exclusively in this fashion.

2. Erection by Dealer

More prefabricators elected to sell through dealer-erectors than through any other distribution channel; 45 companies used dealer-erectors in part, and 25 companies used them exclusively. For 27 companies from which detailed information was obtained, the average number of dealer-erectors was 43.[22] The PHMI in 1945 gave the dealer-erector almost official standing as the preferred type of dealer outlet in a resolution which recognized "the basic concept of selling standardized, brand name homes, mass-produced, nationally advertised and mass-distributed to the mass market through dealers whose functions will include sales, erection, servicing, and mortgage financ-

[22] Of these, one claimed to have 400, two to have 100, and the rest fewer. Five had fewer than five.

ing."[23] Many of the companies were willing to indicate the fields from which they drew their dealer-erectors, and this information is presented briefly here:

35 Contractors or operative builders exclusively
19 Mostly contractors
15 Mostly operative builders
10 Real estate brokers or subdividers
7 "Financially responsible parties"
6 Lumber yards
3 Primarily selling organizations

As might be expected, the large majority had a background of some kind of building.

The reasons for the popularity of dealer-erectors are worth investigating. First of all, as dealers, they enlarged the market area which had to be larger than the immediate area of the factory in order to maintain steady production. In fact it has been pointed out that many experienced prefabricators felt they would have to produce several thousand houses regularly each year in order to attain the full economies of industrialization. A well-organized chain of dealer-erectors was believed to be the most likely way to reach such sales volumes, and it could smooth out the irregularities in orders by covering a variety of areas which the prefabricator otherwise might have to neglect. The manufacturer was also relieved of the responsibility of handling the mass of essentially local problems faced in erecting the house, once the package had been sold. With a well-trained dealer organization putting sales on an efficient basis, the manufacturer could concentrate on production.

Dealer-erectors, while collectively enlarging the market area, were able individually to concentrate efforts within their own relatively limited market areas. Crews did not need to travel far to the sites; factory-method advantages and erection economies could be mastered; site expenses could be held down. Furthermore, dealer-erectors used local labor, which induced greater local cooperation than would the importation of factory erection crews.

To the ultimate consumer, the dealer-erector was a means of avoiding burdensome problems. Almost the only action needed on the part of the prospective buyer was to sign his name to the sales contract and furnish evidence of being a reliable credit risk to the financing agency. The major part of the prefabricated housing industry

[23] *Prefabricated Homes*, 6 (December 1945), 12, reporting the winter meeting of the PHMI in Tulsa, Oklahoma, held December 3 and 4, 1945. Of course, not all members of PHMI distribute in this way.

felt that this was the best way to get houses to customers at the lowest cost, and many indicated that they had evidence that it was cheaper than direct distribution from factory to consumer.

If a manufacturer distributed directly to the consumer, he had to keep a sizable sales force in the field for high sales volume, and then sales expense and commissions rapidly built up his operating expense. In addition, a great deal of additional capital was needed to carry the house packages from the time they left the assembly line until they finally were taken over by the consumer. If the consumer was to erect his house, the house package had to sell at a very low price; if the factory handled the erection, further operating expense was incurred. Well-trained dealer-erectors, making use of efficient selling techniques, cut overall selling costs and were eminently qualified to handle the sizable site-construction job involved in the average prefabricated house. Planning ahead, they could pour foundations in warm weather and thus continue to build houses in the winter season; this would have the obviously beneficial effect of smoothing out the seasonal variations in factory production.[24]

There were, however, some difficulties with dealer-erectors. Most of them had previously been builders, used to working according to local conventions and with local men. As a rule, they were rugged individualists and good builders; they sometimes regarded new erection techniques with disfavor. It was often difficult to persuade dealer-erectors to take a limited profit per unit, on the theory that they would sell many more units, in a seller's market and a period of shortages when many prefabricators found it difficult to deliver the promised volume. Some dealer-erectors were reluctant to tie up their capital in foundations laid in anticipation of inclement weather. Others, not wishing to displease local associates of long standing, tended to buy less than the whole house package, omitting the parts they would prefer to purchase locally. There was at the time of the survey little real stimulus for the dealer-erector to build the sort of alert service organization which prefabricators considered important as a device to take care of minor difficulties once the house has been built.

It was expected that most of these difficulties would be resolved in a stabilized market, but nevertheless many of the large prefabricators

[24] A good example was offered by National Homes, which even in the shortage winter of 1946–1947 was making binding commitments with its more than 100 dealers for three months in advance, and which produced and shipped at a steady rate of never fewer than 2½ units per day. So predictable a volume made possible obvious procurement and production economies.

felt that they would have to develop a new, young, and flexible type of dealer-erector.[25] It was conceded that this scheme would be likely to succeed in the degree that the conventional site work required in the erection of prefabricated houses could be reduced.

Another very common middleman was the lumber dealer who, although not quite like the dealer-erector, yet fitted more closely into this category than any other since he was a dealer who often provided erection service. At least six companies used lumber dealers to handle their house packages. Such dealers were willing to sell the house either directly to the ultimate consumer or to the contractor. If the sale was made to the consumer, the dealer would sometimes arrange to have a contractor with whom he had a working agreement erect the house. In other cases he would erect the house himself, in the manner of the typical dealer-erector. Sometimes, however, the lumber dealer would sell house packages in groups to contractors who intended to erect houses as a speculative investment on land they controlled. In such instances, the lumber dealer was in effect a distributor.

In some cases, for example General Houses (at one stage) or Precision Homes, the preference for lumber dealers reflected the intention of the prefabricator to market modular panels almost in the manner of stock building materials. In other cases, for example Peerless Housing Company, the prefabrication system was in a sense a lumber-selling scheme; and in still others lumber dealers were used in an effort to stay in the good graces of conventional builders. HomeOla, on the other hand, used them because the company marketed by carload lots of five houses, and lumber dealers were able to handle this quantity on a single order.

Whether serving as dealer-erectors or as distributors, the lumber dealers tended to handle houses simply as a side line, and they tended not to make much of a sales effort. Furthermore, they usually were not well equipped to provide many of the specialized services which should accompany the sale of houses. HomeOla estimated that "retail lumber dealers accounted for the sale of only 2,000 out of the known total of 37,400 prefabricated houses sold in 1946,"[26] and the company eventually decided to concentrate on other channels of distribution.

[25] Both American Houses and National Homes, for example, were planning to take well-trained college graduates into their organization for grooming, and then to finance their debuts as dealer-erectors.

[26] The HomeOla Dealer Info-Service, Bulletin M-18 (June 9, 1947), p. 3.

3. Erection by Purchaser

The quantity of sales made by dealers under the terms of which erection was left as the responsibility of the consumer was relatively unimportant. Department stores made a few sales in this manner, but without great success. General dealers operating in rural areas probably sold the most houses to be consumer erected, although Hamill and Jones, which had previously sold direct to consumers, was an example of a company building up a dealer organization but still making sales in some areas for purchaser erection. Pre-Fab Industries had rural dealers scattered over the states of Indiana, Illinois, Ohio, Michigan, and southern Wisconsin who made sales primarily to hatcheries and other "barnyard operators" which in turn distributed panelized houses and utility buildings to their rural customers, and made some of the erections. In a few instances lumber dealers sold house packages to purchasers who assumed the responsibility for erection.

No companies used this system exclusively, and only 14 used it in part. The complications of construction, erection, and financing were so great even for the average well-made unit that this sort of sale was steadily declining. A dealer who took over so little of the burden of marketing from the prefabricator hardly seemed worth the extra markup in price.

C. Factory to Distributor to Dealer to Consumer

A third and major type of distribution system used the services of two middlemen, the distributor and the dealer. In effect, distributors were overgrown dealers who sold to the dealers. They sometimes had a large organization with both a regional and district network, headed by a single main sales force, and sometimes were more localized individuals or companies. There were eight companies using distributors exclusively, and 17 more who used distributors to handle some part of their sales volume.

Distributors added an extra markup to the final selling price of the house, but in many cases they could establish contact with sound dealers more easily than could the prefabricators. Also, individual dealers sometimes sold such a small volume of houses that the prefabricator found the expense and effort of coordinating sales pro-

grams too great. In such a case, one, or a few, distributors would be given the entire marketing job, and it was left to the distributors to see that dealers were supplied. In the case of Texas Housing Co. and HomeOla the prefabricator gave the distributor a 20% discount from the retail selling price of the house package, and distributor and dealer worked out between them what part of the 20% each was to get. It was not uncommon for each middleman to take 10%.

Distributors in other industries frequently have been used to gain nation-wide market coverage, but few prefabricators had seriously attempted nation-wide distribution by this device; rather, it was used to help manufacturers sell in selected markets otherwise inaccessible to the factory. Beyond a 200- to 300-mile radius from the plant some prefabricators felt that distributors could increase sales volume without significantly increasing direct sales expense. For example, West Coast prefabricators found it profitable to use distributors in order to sell in the Rocky Mountain states. This market had not been large enough to support a company sales office or even a salesman, but sales resulting from the efforts of distributors there increased sales volume with few added costs. Such distributors were sometimes manufacturers' agents, selling prefabricated houses as one part of their product line.

The HomeOla Corporation, with a home office in Chicago, used distributors to enlarge its market coverage, making it one of the few companies to reach anything like nation-wide coverage. In seeking this wide distribution HomeOla was greatly assisted by its shipping arrangements, under which all the wood parts for five houses made up a carload from the West Coast and the steel and other parts for five houses made up a carload from Chicago, to be sent by rail to any part of the country. The Texas Housing Co. sold Homettes through 40 distributor organizations, with size of territories ranging from one county to three states per distributor and with minimum sales quotas established accordingly. Dealers were appointed by each distributor, and included lumber dealers, real estate agents, and even filling station operators. Distributors also sold directly to large organizations such as colleges and universities which bought temporary housing units in quantity.

It has been pointed out that lumber yards often acted as distributors, selling the house package to a contractor rather than to the ultimate consumer, and leaving it to the contractor to erect the house and sell it. However, most lumber yards were considered by the prefabricators to be a type of dealer-erector, emphasizing sales

to ultimate consumers and, when they did not erect the house, arranging with a contractor to have the erection performed.

Several prefabricators expected the distributor to become important in the sales plan for modular building components. In order to market such components more directly, however, and to comply with early postwar regulations governing allocation of materials and financing, prefabricators producing them at the time of our survey generally were forced to offer a few standard models in house packages. This was true, for example, of General Panel and of General Houses. With restrictions lifted, a firm financial position attained, and a demand for modular components established, these companies hoped to market the components as such, leaving it to the purchaser to assemble them as he might wish. Since a large inventory of different modular components would have to be carried to meet the varying demands, distributors of strength and size would be needed to relieve the manufacturer of the functions of assembly, storage, financing, and possibly of subsequent resale for secondhand use. Sales would tend to be to contractors and builders, or through established materials outlets which could be expected to stock the components in the manner of standard building materials. Such distribution schemes would, in fact, take the marketing emphasis entirely off the house as such. No such schemes were in full operation at the time of our survey.[27]

The prefabricators were aware of some disadvantages in using distributors, however. As non-builders they added an extra step to the channel of distribution and extra cost to the ultimate consumer, and so the prefabricator had to be sure the distributor could in fact enlarge his market area, reach more dealers, provide cash payments for house packages, and in general relieve him of the expense of a broad marketing program. The prefabricator had to calculate the risks of becoming further removed from the ultimate consumer, of losing close control over his product, and of having his production team grow less responsive to consumer opinion. Furthermore, the distributor might not give as much promotional "push" to the house as the prefabricator himself would give, and he might let the dealer organization become lax and unresponsive to the prefabricator's wishes, since dealers would no longer be directly responsible to him.

[27] Several companies did sell their panels as such in a limited way, however, and many more were perfectly willing to get this additional type of business. As an example of how well the principle can be used, a house by architect Gordon Drake made excellent and efficient use of HomeOla 4′ x 8′ panels (*The Architectural Forum,* 87 [September 1947], 110).

To summarize, prefabricators found distributors a useful mechanism in specialized cases. In general, however, this channel was not considered the most efficient means of distributing prefabricated houses.

V. Sales Methods

The functions to be performed by dealers in prefabricated houses were many and varied. The dealer had to originate the sale, buy the house package from the prefabricator, pay the transportation charges, erect the house, aid the customer in permanent financing, and provide continuing service once the house was occupied. In addition, he had to deal with local labor problems, subcontracting requirements, local building codes, local FHA requirements, and the nature of local prejudice towards prefabricated houses.[28] The manufacturer often found it far from easy to persuade a responsible and cautious prospective dealer that he should take over a franchise.

The manufacturer also had to be careful. Picking the right man to serve as a dealer was not an easy task. Hart Anderson, speaking before a PHMI convention, stated that replies received in response to advertisements from people who want to be dealers are analyzed.

> Some are eliminated at once by the type of letter they write; others are eliminated when they learn the qualifications for dealership, the amount of capital needed and other requirements; credit reports are used to good advantage; and the fourth method is that of going right into the man's home town and finding out all about him.[29]

Manufacturers realized they must use this sort of care in selecting dealers, or it might prove to be better to have no dealer at all.

Some companies had devised rating blanks for this purpose. Gunnison Homes used such a blank, and Anderson presented a form of

[28] In Milwaukee the situation with regard to available land for large projects was such that, in practice, the dealer often was required to find suitable land just outside the city and to wait through annexation proceedings before he could begin his regular work.

[29] Hart Anderson, President of PHMI for 1949, *Report of the Fall Meeting, PHMI,* Grand Rapids, Mich., November 16, 1948.

rating blank to the PHMI,[30] which is given here to illustrate the approach which manufacturers might wish to take in evaluating a prospective dealer.

A reputation for honesty and fair dealing is the first and foremost prerequisite for any dealer-erector of prefabricated homes. In addition the individual or organization should score 80% or more of the following points.

A. Bank Reference and Credit Standing		40%
Does he maintain a satisfactory bank account?	(20)	
Has he a good credit standing with the local bank?	(10)	
Has he a reputation for prompt payment of accounts?	(10)	
B. Business History		15%
Has he a local reputation as a successful businessman?	(15)	
C. Experience and Ability		20%
Is he capable and experienced in home building?	(10)	
Has he experience in land development?	(5)	
Has he good taste in colors and proportions?	(5)	
D. Personality		15%
Has he a good disposition and lots of friends?	(4)	
Is he aggressive and dynamic?	(4)	
Is he amenable to suggestions?	(4)	
Has he business vision?	(3)	
E. Outside Connections and Interests		10%
Is he a director or otherwise interested in local bank or savings and loan associations?	(4)	
Does he belong to Kiwanis, Lions, or other service clubs?	(3)	
Is he active in church or other community work?	(3)	
Total		100%

Prefabricators were careful because they had a good deal of capital invested in their dealers. It was estimated that PHMI represented about $60,000,000 of capital, and its dealers another $36,000,000.[31] One manufacturer had 150 dealers, each one of whom he estimated to represent an investment on his part of $3,500, giving a total investment of $525,000 tied up in the dealer organization; by way of comparison, plant and equipment represented about $1,000,000.

In fact, although the prefabricators generally seemed to spend nearly 50c on dealer organization for each $1 invested in plant and equipment, a smoothly functioning system of dealer organizations had rarely been set up by the industry. The Flanders Committee reported in 1947, "The typical manufacturer today is set up to pro-

[30] Hart Anderson, PHMI Fall Meeting, 1948.

[31] *High Cost of Housing*, pp. 145–6.

duce less than 1,000 houses a year, which he sells to small builders with practically no sales organization." [32]

The manufacturing companies naturally believed that the best type of dealer should combine strength in the fields of sales, erection, and finance, and that he should have strong local approval and support. A sound construction background and a good local credit rating were most helpful to a dealer when his bank evaluated the risk of making construction loans, and left the manufacturer free to make full use of his capital for further production. The problem, however, was to find otherwise suitable dealers who were able to put up the amount of working capital deemed necessary to carry on a successful dealership. Gunnison Homes, Inc., estimated that the dealer in the average market area should be able to supply $15,000 in working capital not invested in fixed assets. Hart Anderson gave even higher figures: "It is thought that the average dealer should have about $30,000 with which to build a demonstration house and for regular operating expense." [33] Other estimates ran even higher. Regardless of the exact amount, the objective of the prefabricators was the same — to find dealers with enough capital to permit rapid turnover and volume sales. Then the dealer could make a satisfactory net profit, and the manufacturer could maintain steady production.

Once a dealer had been selected it was usually considered profitable to have him attend a training school located at the factory. At least 15 companies had special training courses. Such a school accomplished several purposes: the dealer saw firsthand how the house packages were manufactured and thereby gained a better understanding of the product; more important, he was given training in erection techniques and suggestions on the best methods of selling the manufacturer's product. The Gunnison school presented in detail a high-speed selling technique designed to help the dealer sell a house in a very short interview, provided the husband and wife had first read the Gunnison folder. Lustron dealers were also given an extensive training school course which placed a good deal of emphasis on proper erection methods.

After completing a period of training, the dealer was expected to

[32] Wittausch, *op. cit.*, p. 709. Although Mr. Wittausch does not dwell on what constitutes a typical manufacturer, he undoubtedly describes accurately the situation of many of the prefabricators. His remarks do not apply to the few prefabricators who did have good dealer organizations and who manufactured a large part of the total production.

[33] Statement by Hart Anderson, PHMI Fall Meeting, 1948.

establish himself initially through the use of general sales-promotion techniques. Cooperative newspaper advertising featuring the brand name of the prefabricated house and the name of the local dealer was one device used. Usually, the larger part of the advertising burden was gradually shifted over to the dealer, although a few companies such as Gunnison continued to bear 50% of the cost of the advertising in order to maintain better control over the quality of the promotion, prepared mats for newspaper advertising, and sent them out to the dealers.[34] In this connection might be mentioned the program of the PHMI to publicize and encourage the use of its insignia by member companies in their advertising, where it would serve to distinguish in the public mind "the progressive companies dedicated to the production of Modern Homes by Modern Methods." [35]

Another good promotional device was the erection of a model house. Demonstration of the product has, of course, been proved to be one of the best ways of selling, and often orders were placed on the spot after interested persons had examined the house. The house often served afterwards as a sales office for the dealer. Some prefabricators formed the practice of charging an admission fee to go through the model house, in order to discourage miscellaneous and half-interested crowds and to encourage those with a higher degree of interest to look carefully and get their money's worth. It was considered good public relations to turn over all such proceeds to local charity.

One of the first and most difficult tasks facing the dealer was that of finding a way around local building codes and other restrictions, many of which were completely outdated. Interpreted to favor local building groups, and supported by the resistance on the part of many citizen groups to any variety of small houses on the ground that they provide insufficient tax return in exchange for municipal services, the effect of such restrictions had been practically to exclude prefabricated houses from many cities.

The prefabricators as a group reported reasonable success in clearing away restrictions on the sale and erection of their houses, and better success in medium and small urban areas than in large metropolitan centers. Many cities were willing to give prefabrication a fair chance in order to reduce the critical housing shortage. One

[34] Statement by Foster Gunnison, PHMI Convention, Grand Rapids, Mich., November 16, 1948.

[35] *Prefabricated Homes,* 6 (December 1945), 26.

large manufacturer concentrated on small residential communities in large metropolitan areas, finding that these small communities usually had newer building codes as well as a more open point of view regarding new types of housing. It was considered especially helpful if the first house could be sold to a person of importance in the community, or placed on a very desirable site. The house then had a greater acceptance value in the eyes of the other residents of the city. It was also found effective to document one's case with references to other comparable cities which had changed their codes to permit prefabricated houses. Gunnison, for example, made good use of carefully assembled portfolios containing detailed engineering information, examples of favorable code treatment, and references to legal decisions involving appeals on similar points.

The largest prefabricators were optimistic on this subject. Most of them believed that building requirements in codes would soon be expressed, or at least interpreted, in terms of physical performance rather than specification. Equally important in their eyes, however, was the need for uniformity of code provisions and interpretations over a broad sales area. Many would have been willing to abide by an outdated construction specification if they could have been sure of facing the same specification in every area. They were, therefore, interested and active in the growing movement for uniform codes and for state-wide codes, typified in the work of the federal government, the building officials' organizations, and such states as New York, Massachusetts, and Wisconsin.[36]

Once the prefabricated house had obtained clearance from the municipal government, the dealer organization should be ready to employ mass sales techniques.[37] In order to heighten sales appeal

[36] It should be noted that a state-wide *minimum* code, permitting greater local restrictions where desired, was of little use to prefabricators. They were working particularly for some means of setting a state-wide *maximum* as well, so that production could be planned on a house which was sure to comply with all regulations of all communities. At the time of the survey only Massachusetts had set up the legal basis for state-wide provisions of this sort. The Massachusetts law (Chapter 631, Acts 1947) was greatly complicated by subsequent well-intended amendments. Local confusion became so great that in 1950 the legislature repealed the provisions establishing state-wide maxima.

[37] An interesting development in the field of marketing prefabricated houses, which occurred after the time of the survey, was the organization of the Pennurban Housing Corporation. This organization did not attempt to become regular dealers, but urged that the way to achieve mass distribution of prefabricated houses was to start out in major marketing areas with the construction of well-planned, well-located introductory developments. The firm had built three developments, using different kinds of houses, to illustrate its ideas. The pattern

many manufacturers included extra merchandising features in their houses. For example, Lustron included in its regular package such built-in features as a completely furnished bathroom, combination dishwasher-clotheswasher, automatic water heater, furnace, kitchen cabinets, recessed bookshelves, china cabinet, vanity table and mirror, and many cabinets, shelves, and closets for storage. A general trend towards more built-in features was revealed by the survey; most prefabricators, in varying degrees, emphasized them because market surveys revealed them as strong sales points, making the purchaser feel that he was getting more than "just the conventional house" when he bought a prefabricated house. This competitive edge was considered to more than offset the cost of supplying these features.

The sales psychology necessary to sell prefabricated houses in competitive markets had not taken any characteristic pattern at the time of our survey, but manufacturers were paying attention to the methods of the operative builders. For example, Levitt stressed the need of color in the bathroom, efficiency in the kitchen, and flowers near the front door. Kaiser Community Homes dealers encouraged the occupant to beautify the site with shrubs, picket fences, and flowers, and assisted him in such a program. The purchaser was encouraged to build up a "psychological equity" in the house, to assure good upkeep, and to stimulate a feeling of community.

Most prefabricators felt that there was an important merchandising advantage in having a wide variety of models and styles that could be made available to the ultimate consumer. They considered this necessary to avoid the creation of a monotonous group and consumer resistance, or else they believed that the bankers and the dealers considered it necessary. Kaiser Community Homes, using only five basic floor plans, could construct over 5,000 different variations by changing the location of such features as the garage, breezeway, and en-

of operations consisted of the development of a series of pilot projects of modest size (25–50 houses) in the key areas, with the manufacturer providing the required working capital. In establishing a market the outlay of such capital, which should represent a reimbursable investment, was supposed to replace the use of national advertising, which might not give tangible results. Pennurban's developmental work included such things as getting building code and FHA approval for the prefabricated house, handling the site plan and land improvement for the project, and selling a house unfamiliar in the locality. It was considered that this developmental work had to be done only once in any community for any particular prefabricated house, and that competing houses might also benefit from it. Pennurban's operations did not eliminate any of the channels of distribution previously discussed, therefore, but rather aimed at simplifying the initial sales of prefabricated houses.

trances. Gunnison Homes, Inc., offered nine sizes of DeLuxe homes, ranging from one to four bedrooms, with both right and left floor plans, plus garages, breezeways, and such possible extra "architectural treatments" as pilasters, window boxes, and shutters.

One of the most difficult problems in determining sales methods in any new field is to establish the price/quality relationship for the product. This was especially true in the field of prefabricated housing; it was hard to find any kind of agreement among manufacturers as to just how much house should be supplied, and at what cost. In the automotive field, to the argument that the big companies should bring out a car priced to sell for less than $1,000, the president of General Motors has replied that "the trouble with making a car two-thirds the size of a Ford, Chevrolet or Plymouth is that you take out value faster than you can take out cost." [38] The exact point at which manufacturers would begin taking out value faster than cost was hard to determine in the field of housing, especially when the reaction of the ultimate consumer was considered. It has been pointed out that Lustron was taking steps to get a reputation for quality in order to develop genuine consumer demand. Gunnison Homes offered its quality line in the "Buick class" of housing. Many in the industry believed that in the long run the best market was in the middle-income group, in which purchasers would be pleased to find more space and equipment, better construction, better finish, and more built-in features than they otherwise could buy in a conventional house. For the immediate future, however, there were many indications that the price/quality problem could be most profitably solved by concentrating on making and marketing minimum houses at minimum price. The so-called "economy house" was making good money for many a prefabricator.

VI. Financing the Prefabricated Home

During the immediate postwar period procurement and production often were the most pressing problems confronting the prefabricated

[38] Charles E. Wilson, President of General Motors Corporation, *Time*, LIII (January 24, 1949), 78.

housing industry, but the emphasis later shifted. With marketing the most critical problem of the industry, that phase of it which dealt with financing houses seemed the most critical of all. President John Pease of the PHMI warned his members:

> During the past seven months we have seen completion of the transition from a sellers' market to a buyers' market in practically all areas. Many materials, scarce the earlier part of this year, are now available in plentiful supply and at going carload prices.[39]

He went on to say that adequate financing was the problem then needing emphasis.

> Difficulties in connection with mortgage financing of homes was most frequently given as the No. 1 factor limiting sales of prefabricated homes at present in our recent survey of leading housing manufacturers.[40]

A. Financing the Dealer [41]

One reason for the use of dealers was the fact that they freed the manufacturer's working capital for further production. However, many dealers were themselves very hard pressed to raise sufficient working capital to pay for the package at the time of delivery, and, to complicate the picture, they generally did not receive payment from the ultimate consumer until mortgage was secured on the house from a home loan institution. It became apparent soon after the war that some source of credit would have to be established which would permit house packages to be acquired, sold, erected, and turned over to the customer by the dealer. The production methods of prefabrication appeared to have moved ahead faster than the methods of finance upon which the industry would depend for existence.

The shortage of working capital was made more acute by the high unit price of the product. For example, a typical house package might cost the dealer about $4,000 and sell erected, without land, for about $8,000. With ten houses under construction, the dealer would have $40,000 of his working capital tied up in inventory, and he would need additional money for construction. If operations were performed on a smaller scale in order to minimize capital requirements,

[39] John W. Pease, President, PHMI, Fall Meeting, November 15, 1948.

[40] PHMI *Washington News Letter,* October 8, 1948, p. 1.

[41] The financing problems of the manufacturer have been discussed in detail in Chapter 6.

one of the greatest advantages of dealing in prefabricated houses would have disappeared—that of speed in erection, leading to construction of more houses with the same capital, and so resulting in higher profits.[42]

Dealers profited from certain measures which promoted a readier extension of consumer credit, such as FHA approval of mortgages, special arrangements with lending institutions to speed up loans, the construction of model homes for approval by FHA and banks so that similar homes built later could obtain ready approval, and, to a minor degree, the use of acceptance corporations. The Harman Corporation had a somewhat novel plan of financing, making use of a series of sales representatives who were mortgage initiators and thereby in a position to give financial assistance to the contractors to whom they sold and to service these mortgages during the period of the mortgage. The mortgages were usually refinanced in accordance with customary practices through insurance companies or other large financial institutions. Later the company had a wholly owned subsidiary, the Small Homes Development Corporation, which financed builders in housing projects. This program definitely aided sales, but the failure of the parent organization made it impossible to evaluate the subsidiary entirely.

Construction loans were the most usual method of interim financing. But whereas conventional builders customarily had been able to get a line of credit from the materials supplier, we have seen that very few house manufacturers were in a position to grant a line of credit to their dealers. Furthermore, conventional builders could defer many purchases and make them as the building progressed, but the prefabricated housing dealer had to buy an entire house package at one time. And even if a construction loan had been arranged,[43] no payment would be made until the house was shelled in. Most state laws regarded house packages as chattels until they were physically attached to the land and became real estate. The Flanders Committee report summed up:

> The outstanding hindrance to factory sales is the dealer's difficulty in paying for a house package in advance. The usual practice on the part of a local bank in extending a loan to a dealer is to advance him the amount required to cover the cost of the house package after it has been

[42] Pease claimed its dealers could erect four times as many houses as could a conventional builder with the same operating capital. (Interview with Sales Manager, April 7, 1947.)

[43] And many banks were in no hurry to lend money to newly established dealers for distant and, to the bankers, dubious prefabricators.

erected, not before. The period required by the dealer to erect the house package roughly measures the length of time he must tie up his own working capital.[44]

It can be seen, then, that such loans to the dealer had not relieved him entirely of working capital problems.

During most of the period of the survey, loans to manufacturers of prefabricated houses under Section 609 of the National Housing Act had been made on the basis of "binding purchase contracts." This required the dealer to have cash in hand and to have arranged permanent financing for the purchaser—two most difficult requirements. The revised Section 609 [45] offered more hope. As summarized for the industry in the PHMI *Washington News Letter,*

> The amended 609 program authorizes insurance of loans by FHA for the manufacture of prefabricated housing as before. Previously, the dealer purchasing packaged houses was required to pay cash upon delivery. Now, payment may be made up to 30 days after the delivery of the houses. Or, the dealer may pay 20% of the purchase price upon delivery and have the unpaid balance covered by his promissory notes, which are issued to the lending institutions making the 609 loan and which are payable within 180 days from the date of delivery of the house.[46]

In short, interim financing was provided for the dealer. Either plan was a boon, allowing him to expand operations and make fuller use of his working capital; obviously, this was also a boon to the manufacturer. Furthermore, construction loans would more readily be forthcoming, since the banks could be sure of the dealer's credit position. Largely as a result of the careful study of the Flanders Committee, a continuous flow of credit from the manufacturer through to the consumer had been facilitated. This was a significant contribution to the goal of mass distribution, although its full effect on the industry had not yet been felt.

B. Financing the Purchaser

One of the regular functions of dealers in prefabricated houses was to help the purchaser obtain mortgage or other credit so that he could pay for the house. In most cases, it was of the utmost urgency to get

[44] *High Cost of Housing,* p. 158.

[45] Public Law 901, approved August 10, 1948.

[46] PHMI *Washington News Letter,* August 13, 1948, p. 2. See also discussion in Chapter 6, pp. 166–8.

approval of the house by the various offices of the Federal Housing Administration, so that FHA insurance could promptly be issued to cover the private mortgage loan. Increasing numbers of lending institutions preferred not to grant mortgages on houses lacking FHA approval, for several reasons: FHA insurance offered security in case the owner of the house should default in his payments; the FHA had firm rules regarding plan, specifications, and location which served to protect the lender; and FHA-insured mortgages enjoyed a resale market to insurance companies and other large financial institutions. Of the companies surveyed, 76 produced houses which were approved for FHA insurance, and seven more expected approval in the near future.

Another step taken by many dealers was the effort to speed up the financing process. Speedy erections were a sales advantage, as well as the means of achieving a high rate of turnover and a good profit for the dealer on his working capital, but they required speedy financing, too. To this end, the dealer, or prefabricator, frequently negotiated an arrangement with a particular lending institution, or group or chain of lending institutions, to handle all mortgages on his homes. Much the same procedure was used as in seeking FHA approval; the entire manufacturing operation was explained to the officials concerned, and detailed plans were submitted for careful study. At this time the commitment value and percentage of total values were usually agreed upon, and full advantage was taken of the fact that prefabricated housing meant the standardization of plans, both for manufacture and for erection; it was usually necessary to approve only one house to get automatic approval for all others of that type, provided, of course, the prospective homeowner fulfilled the necessary qualifications.

At least 35 companies or their dealers followed the practice of channeling mortgages through lending agencies on this prearranged basis. For example, the Scott Lumber Company spent a great deal of time making preliminary arrangements for FHA mortgage financing terms with certain banks in each sales area, feeling that this was more than justified by accelerated subsequent individual financing arrangements. Johnson Quality Homes had made similar arrangements with the large Dime Savings Bank of Brooklyn.

A device frequently suggested as a means of stimulating the flow of credit is the use of the acceptance corporation. This device is common in the automobile field, where it helped to make mass production possible. However, the situation was different for prefabricated housing, where a much larger sum of money was needed, where

there was almost no established trade in "secondhand models" by the dealer-erector, and where valuation, depreciation, and resale values were far more difficult to establish. Most important of all, prefabricators were confronted with far and away the most conservative branch of the law—that dealing with real estate and the home. Repossessing a home in which a family is living is a problem quite different from repossessing an automobile. The acceptance corporation operating in the housing field has special problems to solve.

Yet the need of investment capital to move the product from the manufacturer to the ultimate consumer was much greater in the housing industry than in the automobile industry, and so the acceptance corporation had been considered carefully by many prefabricators. National Homes, in order to assure a steady distribution for its houses, went on to set up in 1947 a financing subsidiary called National Homes Acceptance Corporation for the purpose of providing long-term FHA-insured mortgage loans to the ultimate consumer and short-term construction loans to National Homes Corporation dealers, making them more independent of local lenders than ever before. The procedure was described as follows:

> When a house is delivered to a dealer, National Homes Acceptance Corporation pays National Homes Corp. for the house. At the same time, the Acceptance Corp. gives the dealer the first of three construction advances. The second advance is made after the second FHA inspection. The third is made upon completion of the house. By this time the dealer will have received credit and advances totaling 90% of the price of the house. The Acceptance Corp. worked out its plan for dealer advances with the help of the American Bank and Trust Co. of Chicago.[47]
>
> The ready secondary market for FHA-insured mortgages now offered by insurance companies makes possible National's one-stop mortgage service for buyers. National is the first prefaber [*sic*] to capitalize on this sure secondary market by making its dealers mortgage *correspondents* as well as builders. VA-guaranteed home loans are also offered by the Acceptance Corp.[48]

National Homes Corporation pioneered in this field, but there was no evidence to indicate whether this practice would spread elsewhere in the industry. It was evident that it would be difficult to raise money in the large sums required to bring acceptance corporations into general use.

Many of the difficulties faced by the final purchaser in negotiating for permanent financing have been general in the housing field, and

[47] American Bank and Trust Co. also made a loan to cover initial operations. The National Homes Acceptance Corporation was later financed by RFC loans.

[48] *The Architectural Forum*, 87 (August 1947), 12.

not limited to prefabrication. For a while there was, for example, a general feeling that actual construction costs had outrun the true value of the completed house. One Savings and Loan official stated that properties were being appraised at 20–30% less than construction costs because this was felt to be a realistic long-range viewpoint. R. F. Talbert, President of the Pittsburgh Home Savings and Loan Association, said in 1948:

> We don't even invite anyone to sit down and discuss a loan unless he has 40% of the purchase price for a downpayment. . . . He must also be a young man and have a good earnings record; and the property he is buying must not be too old or too ultra-modern.[49]

In addition to the need for increased percentages of down payment, another obstacle faced the housebuyer—that of rising interest rates. Claude L. Benner, addressing the Mortgage Bankers Association, stated that an increase to 4½% was necessary to attract investors, and predicted that the rate would be lifted "late" in 1948.[50]

Lending institutions however, were considered by many companies to take an unduly conservative attitude towards granting mortgages on prefabricated houses. Part of this attitude was perhaps fostered by the youth of the house manufacturing industry; bankers had looked askance at some of the earlier examples where the houses were not of conventional design, where the erection was poorly performed, or where the manufacturer suffered financial failure. Possibly banks also felt a responsibility towards conventional builders with whom they had had working agreements over a period of years. It was natural that they should desire to maintain the value of the mortgages held on conventional houses, and therefore prefabricated houses would be resisted if it was felt that they might offer a threat to existing values. This suspicion of prefabrication tended to fade as time went on, but there remained a complaint from many prefabricated housing dealers that the valuation placed on prefabricated houses was too low; and a lower mortgage valuation meant a smaller loan and a larger down payment. Some dealers stated baldly that there was unfair discrimination against prefabricated houses. From the bankers' point of view, there was usually little more involved than the extra caution resulting from unfortunate previous experience.

The valuation problem was everywhere intensified by fears of an inflated price structure in the housing field. Should a recession set in,

[49] PHMI *Washington News Letter,* October 8, 1948, p. 3.
[50] *The New York Times,* September 24, 1948, p. 44.

customers who had overburdened themselves with a mortgage would not be able to keep up the payments. The equity would then have to be surrendered and the mortgage foreclosed. Furthermore, it was the feeling of lending institutions that to ease the financial requirements for mortgages would be merely inflationary, and would add little or nothing to the quantity or quality of housing, but only increase the price.

VII. Choosing the Site

Many prefabricators felt that one of their big advantages was the freedom offered their purchasers in the location of the house. They pointed out that the large-scale operative builder was highly restricted in this respect, because his site had to be large, relatively low in price, and reasonably near a large urban center with a high demand for housing. And many believed that a certain amount of consumer resistance sprang from a reluctance to become a part of a "large housing project"; that very large developments of necessity involved a certain amount of monotony, even though variations of style and floor plans had been used.

These prefabricators also felt, moreover, that they had an advantage over the conventional builder, who could not take on jobs at a distance because of the nature of his operations. For a man doing all his work at the site, they argued, the time required to construct a house was appreciable, varying according to the type of house, the labor force, the availability of materials, and the state of the weather, to mention just a few factors; and for the conventional builder to extend his radius of operations would mean that travel time might soon run up labor costs enough to make the building noncompetitive in price.

By contrast, these men claimed, the purchaser of a prefabricated house was able to pick any site that could be reached by truck and to expect to have a completed dwelling erected on that site. More than with other types of construction, the ultimate consumer was thus free to decide upon the type of community he preferred, whether large or small; since erection time required was much shorter than

for a conventional house, the dealer's small labor force could readily be moved over a wide area.

In many such cases, the prefabricators reported, the purchaser already owned the lot, probably obtained because of its preferred location, and, unwilling to wait for the conventional builder, bought a prefabricated house because it could be erected sooner. In other cases purchasers came in to buy a prefabricated house before they had formulated an opinion about land; in such cases the dealer was in a position to render valuable advice concerning property values, zoning regulations, land improvements, and community character. When the dealer built houses on speculation, of course, house and land were sold at the same time. Often the dealer purchased land, laid foundations, and shelled in houses during the autumn months, and then finished off and sold the houses during the winter months when operations otherwise would have been restricted. Occasionally, the purchaser was buying to replace a house that had been destroyed, or he had some other reason to erect another house on his existing lot. Speed of erection often was the consideration in such a case which brought him into the market for a prefabricated house.

As was true for all housing, conversion of raw land to a building site for a prefabricated house often required a great deal of time and trouble, and in many cases the building site had to be fully improved before loans could be made, lots sold, or erections started. Leveling or terracing, excavating or blasting, stripping and replacing top soil, moving or protecting trees—all these things involved costs and work for the dealer-erector. Furthermore, during the period of the survey, dealer-erectors frequently found it difficult to obtain utilities for their houses. Operating under conditions of severe shortages, the public utility companies often were unable to supply new homeowners with service by the time the house was ready for occupancy. The waiting periods tended to be longest in rural or resort areas where lines had not yet been built, but in almost every type of area the shortages were acute in the early postwar period.

Later, as shortages disappeared, more and more dealer-erectors undertook to develop groups or whole neighborhoods of houses at a time, combining the savings thus afforded in land development costs and in the mass production of houses. The selection of suitable sites for projects of this sort involved a good understanding of local housing demand and of the nature of community development.

In the judgment of some of the largest companies, an important part of choosing such a site involved the possibilities of integrating the project with the surrounding community. In general, local zoning

ordinances had to be studied, building codes considered, taxes on real estate investigated, and private covenants and other restrictive provisions sought out and studied with care. (Many prefabricators had more difficulty with deed restrictions than with building codes.) Local community planning also had to be investigated; the school system and fire protection, police protection, and transportation facilities all had their bearing upon the choice of site for the prospective purchaser's home. Since the average purchaser was not easily able to consider all the items which are important in the choice of a building site, the trained dealer in prefabricated houses could offer valuable services along these lines.

Considerations of this sort were understood by many of the prefabricators, and several indicated that they intended to pay careful attention to site selection principles. Not very many seemed to realize how much good site planning practices, particularly for the first of their houses to be erected in any community, would have to do with the local reputation of the house. For the most part, production problems were so pressing and financial problems so immediate that time could not be found for the creation of favorable local opinion, long-term good will, and the stimulation of better sales in the future.

VIII. Transportation to the Site

The prefabrication industry viewed the transportation problem as a mixed blessing. The fact that his houses could readily be transported made it possible for the prefabricator to use factory production techniques, but, as his volume increased, the cost of transportation itself became a limiting factor. Under the pressure of competitive selling, the manufacturers tended to give closer attention to devising better and cheaper methods of transporting their product to more distant markets.

The operation of transporting house packages was difficult, for the product was large and heavy and the package had to be assembled in the factory to a point beyond which erection crews, using local labor, could easily and quickly complete the job at the site. At least one factor in determining the degree of prefabrication in any system was the desire to avoid having to transport unnecessarily bulky and

awkward packages. The transportation operation was further complicated by the necessity of careful handling to avoid scratched finish, broken or damaged panels, and confusion and loss of the various parts in the erection process. Constant watchfulness was required if the final selling price was not to be pushed too high because of all the elements of transportation cost.

The radius of operations of house manufacturers largely determined the method and cost of transportation, and to a large degree the converse was also true. The survey revealed that 51 companies limited their shipments to an average distance of 302 miles from factory to the site, or approximately the length of an overnight haul by tractor-trailer. Considerations of efficiency led to the common pattern of loading trailers during the day, driving them over the road during the night, and having them ready at the site for the erection crew early in the morning. Another 29 companies relied upon purely local distribution. Although a few companies had hopes of one day attaining national distribution, at the time of the survey no company accurately could be said to have a national market coverage. To quote a writer in the field,

> There are in the industry today less than ten manufacturers who aspire to national dominance. The balance rather conceive their marketing goal to be domination of the territory within a 300-mile radius of their plant, in which they feel they can compete successfully, despite transportation costs, with conventional builders operating locally.[51]

Undoubtedly most of the improvements in transportation methods, which seem necessary if mass distribution is to become a reality, could be expected to come from the companies seeking sales of their houses on a nation-wide scale.

Regarding the cost of transporting a house package, most of the data which follow are based on information supplied by Roy Roberson, of the Pre-Fab. Transit Co., a company which gained considerable experience in doing contract hauling by truck for 15 midwestern prefabricating companies. The data apply primarily to panelized wood houses, although companies producing other types were also among those served.

The first cost consideration involved the number of trailers needed to move a single house package. "The majority of houses are shipped on one truck load. Where the manufacturer ships several accessories, it sometimes takes three trucks for two houses." [52] Much ingenuity

[51] Wittausch, *op. cit.*, p. 709.

[52] Roy R. Roberson, Pre-Fab. Transit Co., Farmer City, Ill., in a letter to the Bemis Foundation, November 30, 1948.

was devoted to fitting the bulky house packages into the various carriers and deciding which items it would be more economical to send knocked down than assembled. The package had to be loaded with due attention to minimum bulk, proper distribution of weight, and protection of fragile items and damageable surfaces. In addition, the method of loading had to be designed in such a way as to facilitate unloading and erection at the site. Of 55 companies surveyed, 30 were able to get complete house packages on one trailer load; 25 companies had to use more than one trailer load. (For the 17 which distributed beyond local areas, this was an obvious disadvantage.)

Although cost per mile decreased [53] with added distance, truck transportation became increasingly costly as the mileage increased; Mr. Roberson felt that it was uneconomical to truck a house package more than 1,000 miles. The Pre-Fab. Transit Co.'s longest haul up to that time was 1,240 miles from Columbus, O., to Miami, Fla., but its most frequent hauls were approximately 350 miles. Its average haul was a little longer than the 302-mile average brought out by the survey.[54]

[53] Cost of transportation per mile was an important fact, but a difficult one to calculate. Roberson described the process as follows: "The average cost per mile is based from our tariff MF-ICC#2 governed by mileage guide #4, Household Goods Carrier Bureau, Inc., Agent MF-ICC#27, supplement thereto or successive issues thereof, as to mileages and distance. (Some use the Triple A Mileage Guide.) These guides give you the exact mileage between all points and places. When drawing up a tariff to be approved by the Interstate Commerce Commission, you must prorate the figures per hundred weight per mile. Our average haul is 300 miles. Our tariff is based on 18,000 lbs. minimum load.

Example:

300 miles at $.75 (rate per 100 lbs.)

18000 lbs. minimum load/
.75 (per 100 lbs.)

90000
126000

$135.00
4.05 Fed. Trans. Tax (3%)

$139.05 per truck load or $.46 per loaded mile.

This varies with total distance. For example, on a 600 mile haul the rate breaks back to approximately $.38 per mile."

[54] Pre-Fab. Transit Co. was frequently used by companies in interstate hauling, because it had the necessary experience to avoid the need for transfer shipping. Many companies used local carriers on interstate hauling. The 300-mile figure used in Roberson's letter was undoubtedly a rough estimate.

The majority of house packages were shipped by truck, rather than by railroad, at least partly because trucks were usually loaded and unloaded more simply than railroad box cars. At least 13 companies used an overhead crane or some type of lifting mechanism in loading; 17 were known to load by hand labor. In either event, open-topped, high-sidewall trailers were easier to load than side-opening box cars, and truckloading did not require the careful protective measures of blocking and stripping required for rail shipments. The most important factor in the use of trucks, however, was their greater flexibility in moving the house package directly from the factory to the site. Estimates of the cost of simply loading and unloading a plywood house for a freight car ranged from $30 up to $100. Roberson, himself a trucker, added, "The increase of rail rates is making it much easier for the trucker to talk cost in the transportation of houses. The railroads are not a definite threat in delivering prefabricated homes. The time element involved proves trucks can make more rapid delivery. As to handling panels, when shipped by rail panels have to be handled three times, and with truck only once. The railroads do not go to the erection sites, so the house must be unloaded onto a truck and delivered from the railroad to the site." Where a long haul is involved, or where the bulk would require several trailers to be used, however, Roberson would admit that the railroad has a better case to present. "At distances of 1,000 miles or more, trucks are offered serious competition by the railroads."

Comparative freight rates were a factor to consider in connection with the railroads, and many companies complained of the high differential between freight on prefabricated houses and freight rates on lumber. Also, freight rates varied by area. There was considerable differential between rates north of the Ohio and east of the Mississippi and rates south of the Ohio and east of the Mississippi, for example. Partly because it was thus favored, the Crawford Corporation of Baton Rouge, La., shipped more than half of its house packages by rail.

For companies with a policy of transporting houses by truck, it became necessary to decide whether to purchase trailers and tractors or to engage contract trucking companies. Many companies found it practical to own their equipment if it could be in fairly constant use. In some cases they found it was good scheduling to load a trailer several days before shipment; if there was a delay, the trailer could be shunted aside rather than unloaded, and the tractor used for other deliveries. A further advantage of ownership was the opportunity of keeping the trailer at the site for use as a storage shed

during the "shelling in" process, thus minimizing the amount of material handling. Since, as Roberson pointed out, trucking companies make their money on volume of miles, contract truckers had to charge demurrage fees for time the trailer remained at the site. The tariff schedule used by Pre-Fab. Transit Co. allowed demurrage claims of $3.50 per hour after four free hours of loading and unloading time. An exception was made in the case of the Lustron Corporation, whose erection crews were allowed 96 hours free unloading time. After 96 hours they were charged $24.00 per day or any part thereof. The Lustron house cost $0.64 per loaded mile for delivery because Lustron used an extremely specialized trailer, designed for this house only.

In deciding whether to buy his own truck and trailer equipment, a prefabricator had to compare purchase price with the cost of contracting for the trucking, including the demurrage charges; and speed of erection and the ability to work out an even flow in production and in the pattern of sales became important factors to be evaluated. At the time of the survey, there was no evidence of a general trend towards either ownership or contracting of trucking; the choice depended on conditions existing within each company.

A matter of concern to prefabricators was the variety of legal restrictions placed by the states on the use, overall dimensions, and weights of trucks and trailers. A house which, in the West, might have been economical to ship long distances in a single large trailer, would require the use of two tractors and trailers in the East, thus making it cheaper to ship by rail. Roberson suggested: "The Interstate Commerce Commission should make all prefabricated house haulers specialized common carriers, such carriers permitted to haul only prefabricated houses. Thus each carrier would have specially trained drivers for this operation only." At the time of our survey, however, the ICC had made no specialized provisions for carriers of prefabricated houses. The average shipping weights of house packages of those companies which reported this information were as follows:

Companies	*Type of House*	*Weight (tons)*
12	Wood frame panel or assembly	13.4
10	Stressed skin plywood	8.3
7	Metal	7.3
1	Paper-cored metal-skinned	2.0
3	Precast concrete	41.0

Many companies had given thorough consideration to their systems of shipment. An ingenious scheme was that of U. S. Homes,

which used large shipping containers made up of steel angles welded together to form cages with a removable side and end, and fitted with swivel casters. Each cage, large enough to contain half of the complete house package, was rolled to the storage bins where panels were loaded into it with hoists and other parts fitted into and onto the load. The panels never left their vertical position from the time of painting until time of erection. When the cage was fully loaded the sides were bolted on, and it was rolled out to the loading platform where two tracks guided it onto tracks on the flatbed of the trailer. A flat charge of $50 was made for delivery of the house within 150 miles of the plant, and deliveries had been made as far as 500 miles from the plant.

Mention has already been made of the distribution scheme used by HomeOla, in accordance with which wooden parts were shipped by rail from the West Coast and steel parts from the Midwest, with these combined freight rates tending to equalize over the nation. Many of the bulkiest parts were eliminated through use of steel beams in the floor systems, and the design was worked out to permit the loading of all the wooden panels or steel parts for five houses in a single railroad car. Dealers were thus able to order in carload lots and so to effect shipping economies.

The Harnischfeger Corporation, needing 1½ truckloads to transport one house package, devised a system of sending on the first load the floor system, structural panels, and all materials necessary to close in the structure, leaving the trim items, kitchen cabinet, and other finish pieces for the next half load. This led to a policy of trying to sell houses in pairs in order to use only three truckloads to transport two houses. In such cases, the floor system of the second house could be sent along with the first load, and the trim and cabinet items for both houses on the second load, with those for the second house temporarily stored in the first house. The panels of the second house could readily be erected since the floor would already be in place when they arrived in the third load.

Comment has already been made on the influence on the industry of the Tennessee Valley Authority's experience in providing mobile housing for construction crews at the sites of its large dams, which required only two or three years each to build and were planned partly in sequence. Some of the TVA houses, after use at one site, had been divided again into their component sections and moved by truck to as many as two subsequent locations in the relatively short time this system was in use. The first TVA houses were built in Sheffield, Ala., in January 1941 and were transported a distance of

60 miles by truck trailer to Pickwick Park. The houses remained in place for two years until a more urgent need caused them to be moved 125 miles to Camden, Tenn. In November 1943 they were moved to Parsons, Tenn. At the end of their usefulness in this location, if not needed elsewhere, they will presumably be moved back to Pickwick Park.

In many ways, prefabricators pointed out, the method worked out for transporting the house had an effect on design. An unusually clear illustration of this interdependency was the house package under development by Acorn Houses, which was hinged and folded into a compact unit for transportation purposes and then simply unfolded at the site with a minimum of erection labor. Another example was the even more specialized unit developed in the Stout house. This was a three-room home on wheels, readily convertible into a trailer, rather than the conventional trailer made into a house. When folded for the road, dimensions were 18′ 9″ in length and 7′ in width. Unfolded, the inside length was 17′ and the width 18′ 8″. One person could easily fold or unfold the house in less than five minutes, thus providing mobility while retaining many of the attributes of a regular residence. Although the Stout house was not a satisfactory permanent residence for most families, it served as a useful innovation, and had a definite appeal to a highly specialized segment of the housing market. Wingfoot Homes also produced a mobile house, although it did not move on its own wheels like the Stout Folding House. Basically a trailer 8′ wide by 26′ long, it was designed to be expanded at the bedroom end to a width of 15′, giving an overall floor area of 256 sq. ft. Thus, from the point of view of transportation, there were two general types of house package: the house package which was shipped largely knocked down into component parts, and the house package which was largely assembled in the factory and came in several sections on trucks or was telescoped or folded to reduce overall dimensions sufficiently to permit it to be handled on the road.

As for the role of transportation in shaping the overall development of the prefabricated housing industry, there was insufficient evidence to point to the existence of any dominant trend. American Houses in 1943 expressed the attitude of a part of the industry:

> A plant manufacturing a thousand standard houses per day can undoubtedly manufacture a house for many dollars less than a small plant which produces only ten or twelve houses per day. Yet this large plant would have to ship over an area much greater in radius than would be the

case with a small plant, and all evidence at hand today points to the fact that the increase in delivery charges for the large plant would actually run its delivered costs per unit beyond those of the small plant. . . .

There should be no "Detroit" of the housing industry.[55]

There was in the industry a great deal of agreement with this point of view, particularly, of course, among the manufacturers of wood houses. Those using metal tended to disagree. It was argued by theorists in the field that such companies might well be unable to decentralize to this degree, but would very likely develop special shipping techniques, designing a compact package of small cube, and shipping the special trailer by train or truck over wide market areas; and further, that companies using concrete might develop a portable assembly plant to be set up temporarily at the site of a project involving a large enough number of units to warrant its installation.[56] Whatever the future may hold, at the time of the survey most prefabricators were operating in a market area within a radius of 300 miles, and they did not feel that they had realized true mass production as yet.

IX. Erection of Prefabricated Houses

The marketing of prefabricated houses was greatly simplified if the design, construction, and transportation plans had been worked out from the start in such a way that each house could be erected soundly and yet swiftly. Indeed, in large projects, many of the same techniques and the same order of efficiency were required as for large operative builders, if the prefabricators were to compete. Timing and coordination between the dealer and manufacturer were therefore essential. This timing usually was the function of the sales department, which maintained close liaison with the dealer, the trucker, and the shipping department, and worked for the ideal situation when dealer's crew and house package both would arrive at the site when the morning whistle blew.

[55] *Prefabrication Explained,* issued by American Houses, Inc. (New York, 1943).

[56] Wittausch, *op. cit.,* p. 710.

As for the erection itself, at least one responsible member of the crew usually had been through the training school at the manufacturer's plant. Where this was not the case, the manufacturer sent a trained specialist out to the dealer to teach the local crew the erection methods; some prefabricators utilized both methods of training crews. At least 24 companies provided training for erection crews, while 53 companies provided field superintendents to oversee erection and to train the dealers' crews on the site in proper erection methods. The field superintendent was found to be extremely valuable during the first few erections performed in the field by a crew.

In several cases companies sent crews out from the factory to each site to perform the erection, theorizing that if company labor could create the house package more cheaply than local labor, it could also erect it more economically. Anchorage Homes tried this technique with its relatively conventional house, and many believed that it contributed to the company's failure. Problems of coordination, transportation, and remote control were too great to permit factory handling of unspecialized erection work.

Most companies placed great emphasis on proper sequence of unloading and erection, usually calculating carefully the manner of loading the package which would most simplify the final erection. It was necessary to make everything absolutely clear, in order to reduce the chance that local crews might haphazardly pull the components off the trailer with no attention to order, and thus bring about costly delays, aimless substitution of parts, and consequent wastage of some materials and shortages of others. When shortages had to be replaced, especially from local sources, the price of the finished house tended to rise quickly. The Pease Woodwork Company made a practice of sending a field superintendent to the site to train dealer crews during the erection of the first three houses. As an example of the degree to which the process was organized, nails of proper size and quantity were supplied, along with a nailing schedule, and much importance was attached to correct nailing technique. The field superintendent subsequently made periodic spot checks on the dealer organizations to make sure that erections continued to meet company standards.

As for the size of the crew required, there was wide variation. The objective generally was to have enough manpower at the site to "shell in" the house completely in one or two days, and crew size therefore depended upon the number of man-hours needed for the erection of a particular type of house. The entire erection crew was not usually made up of specially trained, highly skilled men, al-

though certain complexities did require special training. Prefabricators therefore found it good business to supply accurate figures and plans for erections, and at least 32 companies also provided architectural consultation of some sort in the case of sales of groups of houses, having in mind the importance to the reputation of the house of good site selection and planning. A few even extended this aid to single-house sales.

The time required to erect a house package was significant; every reduction in time cut labor costs and demurrage charges, and increased sales volume. At the time of the survey, the average time for "shelling in" wood frame panel houses was 67 man-hours, in 15 cases; for stressed skin plywood houses 67½ man-hours, in 10 cases; for precast concrete houses 60 man-hours, in two cases; and for metal frame houses 174 man-hours, in five cases.[57] An average of 238 man-hours was required to erect and complete the houses of varying design made by 26 companies. This did not include, however, the work required by subcontractors for grading, foundation, heating, wiring, plumbing, and sheet-metal work, the total of which was generally found to be about the same both in cost and in time as in conventional buildings. The percentage relationship between subcontracted and regular erection work may be illustrated most easily by cost figures. Pease Woodwork Company found that the cost of subcontracting had about the following relationship to the total cost of its house:

Plumbing	10.0%
Heating	10.4%
Decorating	5.9%
Wiring	3.0%
Total	Approximately 30% of cost of house

It further found that 82 man-hours were required to shell in the house, using a crew of three laborers, three carpenters, and one superintendent, and 86 additional man-hours to complete the carpentry work on the house with the same crew.

Erection time was one of the problems that beset the Lustron Corporation. There were some 4,000 pieces in the Lustron package, and the assembly procedure had to be carefully organized. It had originally been hoped that the erection could be accomplished with 150 man-hours of site labor, but the best time that had been achieved

[57] One of the obvious advantages of the truckable houses of the type of TVA, Wingfoot, and Acorn was that they came to the site substantially "shelled in."

was around 250 man-hours. Site labor on initial houses ran as high as 1,000 man-hours, but as standardized procedures were developed a green crew of three men working under a trained foreman could erect the house in 350 hours. In the new models planned by Lustron, considerable attention was being given to reducing the site labor requirements by increasing the size of various components and further simplifying erection techniques.

Another problem in erecting prefabricated houses was that of accumulation of error in dimension through failure to close panels firmly and accurately. Because of this, many manufacturers found it wise to work to negative tolerances in panel dimensions. It was found to be much easier to correct in the erection process for a panel $\frac{1}{16}''$ too small than to correct for one $\frac{1}{16}''$ too large.

The field equipment necessary to erect a prefabricated house was an important consideration, since much of the economic advantage claimed for prefabrication could easily be lost if a great deal of heavy machinery were needed to erect a single house. An obvious exception would be in the case of large projects, where repetitive operations could justify the costs and difficulties of heavy machinery. Most erection processes required no specialized mechanical equipment to handle house components, although quite a few made use of special hand tools. At least 19 companies did require some sort of crane or engine-powered hoisting equipment at the site, however, and truck cranes for lifting panels were found very useful. In general, many wall and roof panels of wood frame or stressed skin plywood and most panels of concrete required mechanized lifting apparatus. In addition, 10 companies used non-motorized apparatus, such as gin poles, hoisting frames, or roller tracks in moving units, particularly for bulky yet fairly light truckable sections. Any vertical panels over 4′ in width were likely to present a problem in a high or gusty wind, especially when the panel construction and material were very light in weight.

The houses produced by 29 companies, because of the heavy specialized equipment and the erection procedure required, were adaptable only to large group erections. An interesting exception, possibly due to conditions of locale, was Normack, Inc. This company manufactured precast concrete houses, normally adaptable only to large group erections, and in local areas; yet it was able to erect houses in small groups up to a distance of 250 miles from the plant, even though the house package weighed from 75 to 100 tons and transportation to the site required five trucks. The concrete panels

were erected by a five-man crew using a large truck crane. Another variant was found in the TVA design, which ordinarily would require heavy site equipment. Here a special hand-powered lifting device and transfer technique had been devised which obviated the necessity for heavy equipment at the site, and made possible erection by single units or small groups. The great majority of companies, however, had designed houses which were easily adaptable to individual erections, and at least 90 companies supplied house packages which required no specialized heavy handling.

X. Service to Customers after Erection

In order to offset doubts on the part of consumers and lending institutions regarding new production and construction methods, and to take advantage of a large, well-trained, and continuing organization, some prefabricators arranged to provide service to the house for a period of six months to a year after occupancy. Several companies even guaranteed their houses for such a period of time, providing service free of charge during the time of the guarantee and at a low cost after that. Among conventional builders, a guarantee was common, but few could back it with comparable resources. Such a plan proved very worth while as a means of instilling confidence among the dealers, and also helped establish the brand name and reliable reputation of the prefabricator. Other companies found it profitable to keep a small number of men on the payroll with the responsibility of servicing all complaints on the houses. In this way the manufacturer gained valuable knowledge both of the technical "bugs" in his design, and of the general consumer reaction, whether favorable or critical.

Precision-Built planned to set up a special fund towards which the purchasers would contribute as a part of the original price of the house. The house would be guaranteed for one year, during which time all services would be provided free. All the service deposit which was not actually used up in making service calls would eventually be rebated to the dealer in the form of a bonus, thereby giving him an incentive to do a careful job of original erection.

Gunnison offered a good illustration of a company providing continuing services for the homeowner, much like the services provided by automobile dealers to car owners. Services included painting, joint checking, furnace checking, and roofing. Each house was sold with a registered number, and a continuous record was maintained for each; not only the original owner, but subsequent owners also, stood to benefit from this type of control over the service performed. In a speech at the PHMI Fall Meeting, 1948,

> Mr. Gunnison said that in his opinion the most important thing is a satisfied customer. He emphasized three other important requirements for success—namely, a good product, a dealer of integrity, . . . and continuing service on the home. He said that Gunnison Home owners are encouraged to write to his company about their homes whenever some maintenance is needed. These letters are analyzed carefully and standard bulletins are prepared for dealers on how to service homes. He said when anything of a more serious nature goes wrong, . . . they contact the dealer and if he is unable to take care of it, they have one of their own field men go to visit the owner and personally inspect the house. . . . They have a one year warranty on their home and at any time during that period any replacements are made without charge. The dealers are required to grant six months of free service. This servicing, while costly to begin with, does more than anything else to inspire confidence of the owner in the product. . . . Buford Bracy of Bralei Homes, Inc. [addressing the same PHMI meeting] stated that they . . . show the home owner how to operate all the utilities, point out to him ways of improving the appearance of the house, and give him an unconditional guarantee for 90 days. . . . They warn the new home owner of such things as a sticking door or a water faucet that leaks slightly and request him to make a note of such things and give them a list so that their field service man can attend to all of them at one time. As a result of this close cooperation with the home owners, Bralei Homes has received many repeat orders and other orders come as a result of the recommendations of satisfied owners.[58]

A service of a slightly different type was occasionally offered new homeowners by prefabricators: the new occupant could go to a department store and buy the complete furnishings for his home, all in one specially prepared package. Under this plan the store would collaborate with the manufacturer, using interior decorators in conjunction with architects and designers, to provide the ultimate consumer with furnishings which fit the home, and offering several types of decorative plans for any given house. Macy's, Gimbels, and Wanamaker's had cooperated in such schemes. This type of service cost the occupant of the house no more than if he had him-

[58] *Report of the Fall Meeting, PHMI,* Grand Rapids, Mich., November 16, 1948.

self picked out all his furnishings, and usually offered him a far better value. Both the manufacturers and the department stores felt that this plan often was a sensible method of merchandising.

The trend of the industry seemed definitely to be in the direction of giving the ultimate consumer a "turnkey" house, and to have the dealer relieve him of every possible care and bother, including continuing services to be provided by the dealer and the manufacturer after the house had been occupied. When competitive selling was more acute, all felt that these services would assume even greater significance.

XI. A Review of Failures

Wide publicity has been given to the fact that of the several hundred companies which were taking steps to get into the production of prefabricated houses in the first year or so after the end of the war, the large majority either never got into production or, having started to produce houses, failed. In Chapter 3 on the Postwar Period (p. 71) some estimates have been given of the actual numbers involved in this sharp process of attrition.

In order to examine somewhat more closely the nature of these failures and their relation to marketing, however, a special check of 100 companies was made, including those generally considered to be among the soundest, in order to see what had happened to them during the period of the survey. It was found that of these hundred, 42 either had failed or were no longer engaged in the manufacture of prefabricated houses. It was not possible to specify in each case a single reason for failure, and in some cases not even general reasons could be clearly defined; it was possible, however, to draw certain broad conclusions and to underline a few simple truths.

Of the 42 companies, at least 12 never got into production at all; most attributed this to lack of financing. It might seem that they, at least, never faced marketing problems. Actually, their financing problems were often tied in with contemplated marketing problems. For example, Fuller Houses, widely publicized as having a good chance to revolutionize the industry, built only two houses, and its

failure was generally, and accurately, attributed to the lack of capital.[59] At the same time that Fuller was failing, however, millions of dollars of RFC money were being made available to Lustron. The difference between the two lay largely in the fact that FHA would not approve the Fuller house for mortgage insurance and, later on, that NHA would not approve a remodeled and simplified version of the house for RFC loan purposes. Doubts about marketability undoubtedly were responsible for these financial difficulties.

Three of the companies which never got into production chose not to do so because of management decisions that marketing problems would be too great. Two companies producing a line of steel building components seriously considered making prefabricated houses, and decided that the costs and difficulties of marketing houses could not be justified by the probable profits; they decided to remain in the simpler and more profitable components business. Vaux Wilson, of Precision-Built, had announced publicly that in his opinion the costs of labor and materials were too high and the quality too low to permit him to produce a house in the required price range. Two other companies had never intended to produce houses themselves, but only to license their schemes for production by others; licensees proved not to be forthcoming.

Many of the failures were clearly not attributable to marketing problems, however, and many more were bound up with considerations other than marketing alone. In at least three cases, the companies were reported to have had very inexperienced and unintelligent management. Four others tied up a large part of their capital in development and in plant costs, only to fail for lack of funds with which to operate. Four companies found materials shortages too difficult to overcome. And at least one simply failed to reopen after a fire had wiped out a major part of the production plant.

In at least 12 cases, however, marketing was flatly given either as a sole reason or as a large contributing reason for failure. (These included some of the cases mentioned above as never having got into production.) One of the most publicized failures, excluding those of Lustron and Fuller, was that of Harman, which, in its voluntary petition in bankruptcy filed on November 30, 1948, stated: "We attribute the Company's failure to its inability to overcome the complexities of distribution and the difficulties of financing sales and erection. Production and consumer acceptance of our houses has never presented a serious problem." General Plywood, in abandon-

[59] "What became of the Fuller house," *Fortune*, XXXVII (May 1948), 168.

ing its small postwar house, felt that it had a product with poor sales appeal, and also that it had made a serious mistake in committing itself publicly to a selling price which could not be realized as the house went into actual production.[60]

In most cases, there were several inter-related reasons for failure. The Green's Ready-Built house, one of the better designed and more carefully finished houses, appeared not to have broad sales appeal, and further than that, in a candid appraisal of its difficulties, the company admitted that it had not made an adequate allowance for expense of selling to dealers. To set up dealer organizations, and to get the houses moving to these dealers and through them to the ultimate consumers, required well-trained men able to devote a good deal of time to the work, and the cost of these men had not been allowed for.[61] In the case of Anchorage Homes, a number of reasons were given for failure. There was a wide feeling that the management had changed too often and many of those involved had been too inexperienced. Certainly, the investment of at least half a million dollars in a new plant had consumed capital badly needed for inventory and for marketing expenses. And the original Anchorage theory of handling erection with special crews sent out from the factory had proved inefficient and costly.

Of the companies still in operation at the time of this special check, there were several which were faced with marketing problems of very large proportions. Admiral Homes, Inc., had found it too difficult to sell stressed skin panelized houses and had turned to partial precutting and conventional framing.[62] Dealers for two of the hopeful new companies had protested that management was far too unconcerned about the problems of marketing, and likely to find itself in difficulties. And the most publicized of the prefabricators, Lustron, had been refused additional loans from RFC[63] and was

[60] Estimated selling prices for new prefabricated houses were always of great interest to the reporters of the newspapers and magazines. Prefabricators soon learned to refuse to authorize the release of any price estimates whatsoever, and those whose early estimates were published had reason in every case to regret it, in a period of general inflation.

[61] It was estimated that in the early stages these wholesale selling costs would run over $500 per house. This may be compared with the figures in Tables 2, 3, and 4 at the end of Chapter 9. It was expected that, as the company became successful, these selling costs would decline.

[62] With this partial change in design and with a new emphasis on sales, Admiral later substantially increased both production and profit.

[63] Lustron had been lent $37,500,000 in all, and some officers of the RFC had indicated a willingness to increase the loan to as much as $50,000,000 in order

ordered sold at auction, the object of a number of investigations and of complex legal wranglings which included a battle for jurisdiction between the federal courts of Columbus and Chicago.

Many reasons have been advanced for the failure of Lustron, some of which have been suggested in other parts of this study. There can be no doubt, however, that a major contributing factor was the failure of the company to establish an efficient marketing organization. The company always proclaimed that the house would sell itself, but many a former dealer has complained that, with a well-designed product to sell and a long list of customers willing and able to pay, it was not possible to get firm commitments on delivery, or to schedule deliveries in such a way that local erection teams could be trained in the new techniques involved. The serious attention of the company seems not to have been turned to the initial difficulties and the many practical suggestions of the men who were most important to its success—its dealers.

From the failures among the prefabricators at least one ray of hope could be derived, however. One midwestern dealer spoke for many of his kind when he reported to us that he preferred to do business only with companies which had gone through bankruptcy. They were the only ones, he said, which understood very clearly the facts of life in the prefabrication business, and with them he felt the chances of success looked good.

to get the marketing mechanism in operation and to realize a return on the federal investment. This proved not to be possible, however, and it will never be known whether more capital would have saved the day. It is interesting to note, however, that the original estimate of minimum capital requirements made by Strandlund in planning the organization of Lustron was $54,000,000.

46 *National Homes thrift model*

47 *Two other economy models*

1 | *Gunnison*

2 | *Harnischfeger*

1

2

3

4

5

6

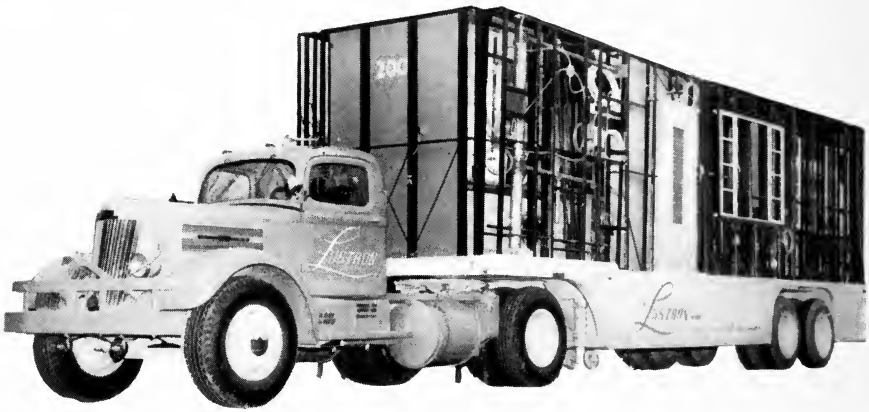
48 *National Homes house being erected*

1 *foundation prepared*
2 *floor laid and panels unloaded*
3 *wall panels erected*
4 *ceiling panels holding walls and partitions in place*
5 *preparing for roof panels*
6 *erecting roof panels*
7 *placing gable-end panels*
8 *finishing the house*

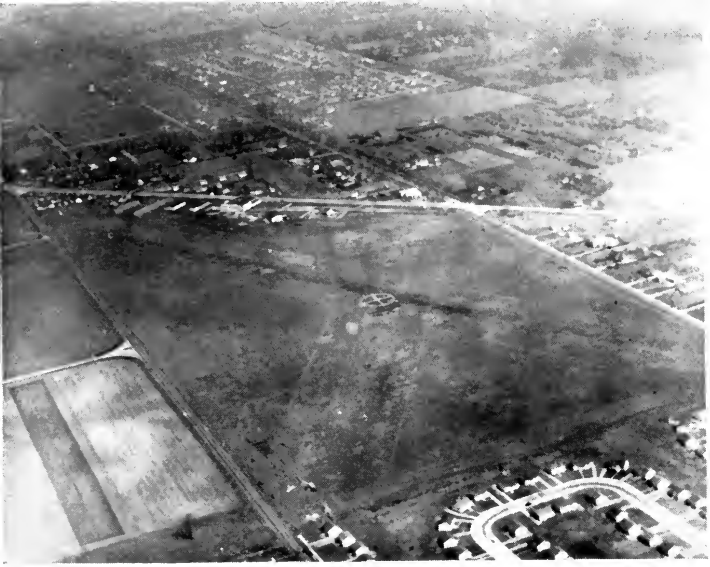
7

8

49 *Lustron house en route*



50 *National Homes house en route*

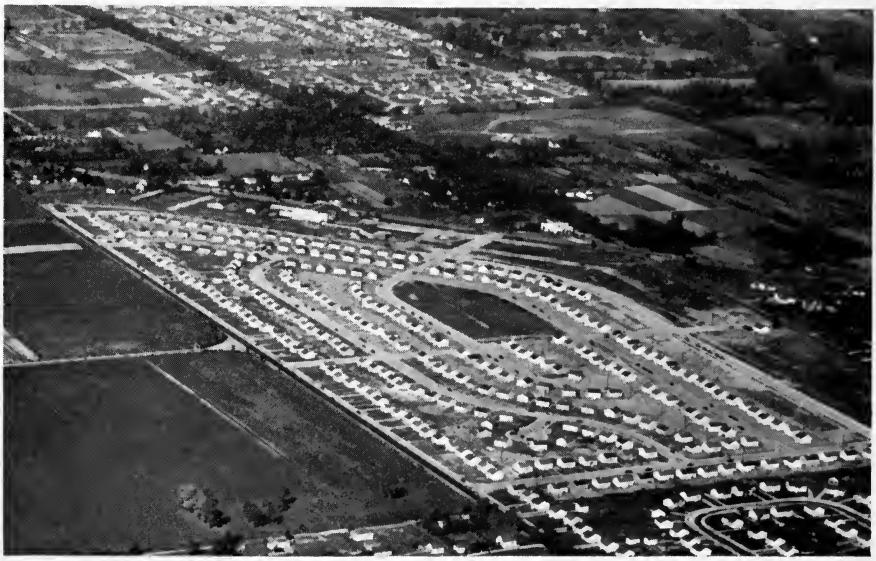


1 the site in March, 1949

51 *The development of a National Homes project, Indianapolis*

2 construction under way, May, 1949

3 *project finished, October, 1949*



52 *Lustron house being erected*

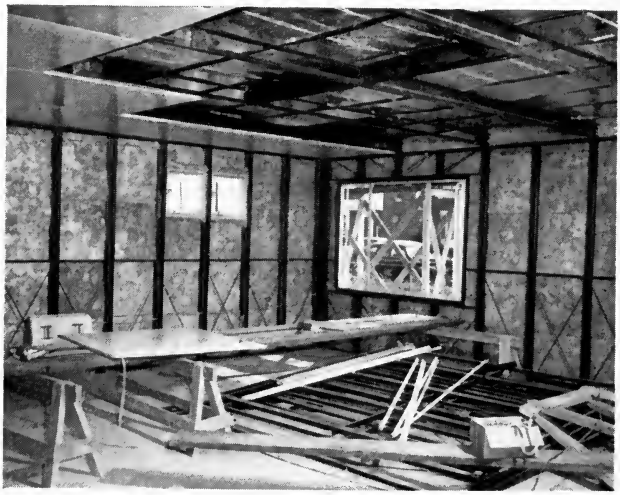
1 *placing frame panels on foundation slab*

2 *bolting frame panels in place*

3 *putting roof trusses in place*

4 *putting plumbing wall panel in place*

5 *applying exterior panel cladding and finishing details on Lustron house*



6 *view of interior with ceiling plenum chamber unfinished and no interior wall panel cladding applied*

Part II.

Chapter 11

CONCLUSION

As this book goes to press the prefabrication industry, though its problems are far from solved, is nevertheless generally optimistic. A PHMI survey of 31 member companies in 1949 reported that the following factors continue to limit the sale of prefabricated houses:

Interim financing still remains the No. 1 problem, being listed 10 times; scarcity of mortgage money was listed 6 times; FHA delays were listed 6 times; the attitude that prices will drop later was listed 4 times; the problem of distribution was listed 3 times; the education of builders was listed twice.[1]

Final reports for the year were encouraging. It was estimated on the basis of a survey conducted by PHMI that the industry shipped a total of 35,000 permanent dwellings during 1949, an increase of 16⅔% over the figure for 1948. The estimate was based on reports from 89 companies, 85 of which produced houses made primarily of wood. The four metal-house companies were estimated to have produced 2,500 houses during the year.

About one quarter of these companies shipped more than 300 houses during the year; some of these were among the country's largest producers of houses, with four shipping more than 1,000 during the year. These large companies were rapidly expanding their distribution area beyond the normal 300–500 mile range, and nearly half of them were able to distribute on a regional basis. The typical house shipped had a floor area of 768 sq. ft. and was priced at $7,000 erected and finished, but less price of the lot.

During the first half of 1950 the record was even more encouraging. Reports from member companies of PHMI showed that shipments had increased 215%, while production for the housing industry as a whole had increased in the neighborhood of 50%. It was estimated that 28,000 houses had been shipped by prefabricators during this period, as compared with 35,000 for the entire year in 1949.

Although most of the companies in the industry made gains, the sharp rise in shipments stemmed largely from the tremendous gains made by a handful of companies. National reported shipment of 3,565 houses during the first six months of 1950, as compared with 4,435 in all of 1949. Gunnison reported sales up as much as 800%.

The state of the industry is well reviewed by Joseph M. Guilfoyle in the *Wall Street Journal*, February 8, 1950:

Whirring saws in prefabricated housing plants are humming a comeback tune.

[1] PHMI *Washington News Letter*, November 4, 1949, p. 2.

A year ago this industry's bright promise of cheap mass-produced houses seemed to be dimming fast. Output, which had slumped to an anemic 30,000 units in 1948, was sinking even lower in the early months of 1949. But in mid-summer the trend reversed itself. By the end of the year, the 85 firms active in the industry had shipped some 35,000 units, only 2,000 fewer than the record number turned out in 1947.

This year's goal: A minimum of 50,000 houses.

What's sparking the industry's revival?

Prefab men credit the introduction of the low-cost "thrift" or "economy" type house selling from $5,200 to $9,000 or so—after figuring in the price of a lot to put it on. At least 75% of the industry's output this year will consist of these low-cost houses. The second big factor fanning the recovery flame is a changed attitude among conventional builders. Explains a prefab manufacturer:

"Small local builders are more receptive today to the idea of putting up prefabricated houses than ever before."

Typical of the industry's resurgence is the experience of National Homes of Lafayette, Ind., largest producer of factory-made homes in the country. In January it made three times as many houses as in the similar month last year. It has orders for approximately 10,000 dwellings to be delivered in 1950. During all 1949, the company sold 4,435 houses.

American Houses, one of the oldest firms in the industry, expects to ship three times as many dwellings in the first quarter of this year as it did in the like period a year ago. American's goal for all 1950 is 7,000 units, 4,000 more than it made last year. . . .

To handle this increased business, a number of makers are launching expansion programs. American, for instance, which now has plants at Allentown, Pa., and Cookesville, Tenn., is putting up a new factory at Lumberton, N. C. It will go into production about March 1. . . . National Homes, which last year increased its capacity from 28 houses a day to 40, will put two new plants into operation in 1950, at Horseheads, N. Y., and Lafayette, boosting daily output to 120 units by next year. . . .

There remain important segments of the industry—well known firms and others of less fame—that are having trouble. Most notable is Lustron Corp., which makes pastel-colored steel homes in a great Columbus, Ohio, government-owned plant. It is under threat of foreclosure from the R.F.C., to which it owes $37,500,000. Among the smaller firms now producing less than a year ago is Nichols & Cox, of Grand Rapids, Mich.; it blames its cutbacks on a disastrous fire last year. Capital Prefabricators, Inc., of Tyler, Texas, says it operated at a loss last year; it aims to hike output in 1950. . . .

Looking back over the past year, most prefabbers agree the industry's shift to the cheaper house gave it a new lease on life. Harnischfeger Corp., of Port Washington, Wis., for example, reports the upturn in its business last spring coincided with the introduction of an "economy" house which sells from $5,500 to $8,500 without land. (The price of a lot can of course vary widely, but prefabs usually land on lots costing under $1,000.) Previously, the company had been making Cape Cod type dwellings in the $10,000 to $15,000 price range.

One of the first firms to hit the market with a low-cost dwelling was National Homes, which brought out its "thrift" house in November, 1948. According to James R. Price, president, 90% of National's output is in the $5,300 to $6,000 price bracket. Land, of course, is extra.

To keep the sales ball rolling some manufacturers are developing even less expensive dwellings. American Houses, for example, which makes a two-bedroom house tagged at $6,000 to $7,500, will hit the market with a new low-cost unit this spring. This dwelling will have a steel frame, aluminum trim and walls of gypsum sheets. The roof will consist of a flat sheet of steel covered with asphalt. The new units, at the outset anyway, will be aimed at the rental market.

"We've been working on this house for two and a half years," comments American's president, John Taylor. It is designed so several can be linked together into a one-story apartment building. "I'm convinced we can build good two-bedroom apartments to rent for less than $60 a month. A trial unit of 14 apartments to rent for $40 a month is under construction now in Richmond, Va."

Next to the lower price factor, prefab men consider the most important development in their industry is the increasing interest conventional builders are showing in their product. . . .

American's Mr. Taylor explains: "Not long ago the average conventional builder took the view that his putting up a prefab house would be like the Waldorf-Astoria buying its groceries from the corner store. It simply wasn't done. But now there's a noticeable change of heart. The builder's in a competitive market and is beginning to realize the need for better designs and construction methods and reduced overhead. As a result, we have nearly twice as many builders using our product as a year ago."

How does a prefab manufacturer win over a conventional hammer-and-saw builder? [E. E. Kurtz, general manager, Thyer Manufacturing Corp.]:

"When selling a conventional builder we point out that with the same amount of effort he can supervise a greater number of units during the construction stage and thereby increase his profits. By completing our houses in a shorter time he can cut down his own investment, or if he is using funds obtained from a local financial institution, the interest will be reduced."

[William B. F. Hall, president of General Industries, Inc., of Fort Wayne, Ind.]:

"We prove to a local builder that he can build five times as many houses at the same margin of profit and on the same amount of invested capital and supervision that he is using now."

What's the experience of builders who have succumbed to such sales talks? Mario Pizio of Pizio Bros., located in North Syracuse, N. Y., which took the plunge in 1948, gives this report:

"In 1947 when we were building in the conventional manner we put up six houses. The next year, our first in the prefab field, we built 41 dwellings. In 1949, we jumped that to 81 and this year we're planning at least 125 units. By using prefab parts we found we could erect a house in less than 30 days, compared with the three or four months it took when we did the job the old way. Our capital is tied up only a third as long as pre-

viously and our overhead has been reduced substantially. I think that in 10 years 50% to 60% of all houses will be prefabricated."

In the last 10 months, says Mr. Pizio, four major real estate firms in Syracuse have become prefab dealers.

Builder Francis Marelli of the Marbro Construction Co. in Rockford, Ill., makes this additional point:

"One of the reasons we got into prefab building was because it was the only way we could control our costs. When we start a job now we know exactly what our costs are and—more important—we're sure they won't jump up on us midway through the job."

Builders also report the elimination of material delivery headaches. Ludwig Bloch of the Duke Construction Co. in Richmond, Va., says: "We can work out a time table for shipment of the prefab package and know we'll get it on schedule. When we built conventionally we always ran the risk of having the material dumped on us before we were ready for it or getting it too late. Either way, it would cost us money."

Many builders turned prefabbers don't advertise the fact they're now using factory-made parts. One manufacturer relates how a builder, when asked by a prospective customer if she was being shown a prefabricated house, replied: "Oh, no. This is a pre-assembled house."

National's Mr. Price takes this slant: "We do not stress the word 'prefabrication' since we feel the term is unimportant. Our builders advertise they are dealers for National Homes Corp." . . .

Codes and zoning regulations, though still a problem, are becoming less restrictive. "Most localities throughout the country," reports Harnischfeger, "either have changed or are in the process of changing their codes so as to benefit from technological improvements."

The manufactured house, whether partly or almost wholly prefabricated, is no longer merely experimental. It is a potent and still evolving factor in housing today.

Appendix A

PROCEDURE

At the time this study was undertaken, the files of the Bemis Foundation, incorporating those of the earlier Bemis Industries, Inc., and kept up to date with care, probably represented as rich a source of material on the prefabrication industry in the United States as was readily available in one place. Nevertheless, it was obvious that much of the information which would be needed for a thoroughgoing analysis of the industry could be gathered only by supplementing this material with actual visits to the factories and offices in which the industry was taking shape. There was no acceptable substitute for an inspection of production facilities, an examination of the product, and a discussion with the men charged with selling, financing, and erecting it.

To carry out the field survey of the industry, the Foundation named Herbert S. Heavenrich, Jr., a structural engineer and student of prefabricated housing on leave of absence from the Houses Division of the Harnischfeger Corporation. After two months of study Heavenrich prepared a questionnaire form for use in conducting the interviews and in assembling related information with regard to the various prefabricators. This form is reproduced here in full, incorporating a few minor changes which were made in the field.

COMPANY _____

MANAGEMENT

1. Staff
   (a) Positions and organization
   (b) Training and background of key men and history of the organization
   (c) Projected organization
   (d) Meetings of staff
2. Capital structure of company and investment in plant [1]

[1] Information usually obtained by indirect sources.

3. Projected plant expansion or new plants
4. Resistance or encouragement encountered, and concessions made in order to operate
   (a) Public
   (b) Material dealers and producers
   (c) Real estate brokers
   (d) Finance organizations
   (e) Codes officials
   (f) Local, state, and federal government officials
   (g) Unions
   (h) Operative builders, contractors, homebuilders associations
   (i) Zoning laws
   (j) City planning commissions
5. Activities in, or relations with
   (a) Public relations
   (b) Advertising
   (c) Code revisions
   (d) Civic committees
   (e) PHMI
   (f) Other professional or commercial groups
   (g) Market research
   (h) Government policy steering
   (i) Exchange of information with government agencies, other manufacturers, research groups, PHMI
   (j) Design research, scope, and objectives (including attitude towards design changes and basis of evolution, i.e., yearly changes, continuous changes, radical long-term changes, and their acceptance by the market)
6. Opinion of competition and opinion as to size and nature of ultimately successful organizations

DESIGN [2]

1. Classification of system [3]
2. Description of system
   (a) Architecture (including number of stories)
   (b) Basement or foundation system
   (c) Floor [4]
   (d) Walls and partitions [4]
   (e) Ceiling [4]
   (f) Roof [4]
   (g) Mechanical equipment and method of installation
   (h) Heat, sound, light, and ventilation conditions

[2] Many of these questions were inspired by the questionnaire suggested by John E. Burchard in the survey described in *The Evolving House*, published in 1936.

[3] This usually referred to major structural material and structural system of exterior walls.

[4] Under five categories:

(i) Frame assembly
(ii) Frame panel
(iii) Stressed skin
(iv) Solid panel
(v) Cast *in situ*

(i) Built-in furniture
(j) Garage

3. Planning—present models [5]
   (a) Kitchen-dining rooms
   (b) Size of sleeping rooms and relation to bathrooms
   (c) Storage arrangements
   (d) General economy of space
4. Number of models or quality standards, or types of buildings offered on market simultaneously. How much design flexibility is achieved?
5. Amount of labor and material to be provided by dealer, or at site, in addition to manufactured parts
6. Extent of parts interchangeability with reference to repairs and installation of new developments [6]
7. Degree of materials reclamation ultimately practicable [7]
8. Adaptability to fit changing needs of occupants
9. Weather resistivity and adaptability to all climatic conditions
10. Efficiency of structural design with respect to load bearing
11. Is insulation adequate?
12. Moisture and condensation problems
13. Innovations vs. complexity (i.e., does desire for patentable features or just "to be different" cause unnecessary complexity?)

PRODUCTION AND PROCUREMENT

1. Description of flow of materials
   (a) Raw material sources. What savings are effected, if any, in distribution of these materials as compared to system of materials distribution to conventional builders?
   (b) Raw material handling methods at factory
   (c) Fabricating processes
   (d) Number of rejects and cost of inspection
   (e) Finished goods handling and storage system. Storage space.
2. Production control system
3. Availability of materials used and price trends on them. What materials would be substituted if their price declined to level of present materials?
4. Labor price reductions through lower hourly factory wages and higher efficiencies per man-hour [8]
5. Extent of mass production achieved. Is system all-inclusive enough, or will it soon be, to effect real savings? [9]
   (a) Centralization of production
   (b) Are factory production methods used in transferring fabrication of parts from site to factory, and are they more efficient?
   (c) Are utilities more cheaply installed than in conventional homes?
   (d) Do materials lend themselves to mass-production method in factory?

[5] General discussion, if any; plans usually were available. So many floor plans were standardized that comment was unnecessary in numerous cases.

[6] Ordinarily not featured to any greater extent than in conventional housing.

[7] Not usually a consideration.

[8] Answer not usually directly available. Wage rates and man-hour figures usually obtained here.

[9] Ordinarily, this was a general discussion, or comment, on the amount of vertical integration achieved.

6. Finished articles bought by the manufacturer and supplied with house and at what savings? (e.g., cabinets, bath and kitchen fixtures, siding, shingles, paint, wallpaper, and heating units)
7. Costly equipment employed. General availability and cost of production equipment (e.g. hot presses) and plant.
8. Months of year work proceeds, shipments made, and erection done
9. Plant size

MARKETING

1. Cost of product and of marketing same
2. Marketing process
   (a) Dealer organization and relationship to manufacturer. Origin of dealers.
   (b) Dealer training and sales kits
   (c) Exclusive or general franchises given? Type of contract?
   (d) Anticipated changes, if any, in dealer organization as product changes. Amount of building done by prefabricator, if any.
   (e) Warehousing
   (f) Expansion of plant system
   (g) Coordination of sales, shipping, and production
   (h) Engineering and management aids to dealers
3. Shipping
   (a) Weights and cubes
   (b) Packageability
   (c) Radius
   (d) Costs
   (e) Schemes (i.e., by rail or truck, what % of each). Special arrangements for minimizing costs.
4. Erection process
   (a) Training of crews, and skill required. Number in crew.
   (b) Field labor man-hours for shell erection
   (c) Field equipment necessary
   (d) Time required for erection, complete and ready for occupancy
   (e) Adaptable to group or individual erections?
   (f) Foundation preparation
5. Type of market pursued
   (a) Price range
   (b) Rural, urban small, metropolitan large?
   (c) Sale or rental
   (d) Group, or individual mass sales?
6. Service and maintenance provided by dealers or company
7. Methods of financing dealer purchases
8. Methods of financing consumer purchases
   (a) Dealer tie-ups with private finance agencies
   (b) Use of government aid
   (c) Innovations, "package mortgages," shortening of time required to process mortgages
9. Market attitude towards acceptance of new models of unconventional appearance and plans for same. Methods of education for this purpose.
10. Export plans
11. Seasonability of sales

The list of companies and offices to be visited was prepared from the files of the Foundation, supplemented by lists prepared by government agencies, trade publications, and periodicals. With only minor changes, this was the same as the list of companies actually visited, given in Appendix B. The geographical distribution of companies indicated that the field survey would have to include most of the major cities in the United States, and plans were made accordingly, with letters of introduction sent out in advance and definite appointments arranged wherever possible. Heavenrich spent seven months in nearly continuous travel during this phase of the survey, and he and other members of the Foundation staff later revisited many of the major companies and visited other companies which had not been in existence at the time of the first trip.

The usual procedure in a company visit was to talk with the president or general manager, and often with specialists in design, production, or marketing, spending one day with each company. From notes filled in on the questionnaire form, extensive typewritten reports were prepared on each company, with careful indication of information given to the Foundation in confidence. Heavenrich supplemented the 165 reports which he made in this way on companies and public or private organizations with 130 reports on smaller companies and dealer organizations which were based only upon telephone interviews.

Information gained in this way was not always complete for each company: some companies had not fully determined their pattern of operations or gathered statistical data of any value; other companies were not yet in actual production; occasionally it was not possible to obtain all the desired information in the time available. In most cases, the interview material was supplemented by company plans, specifications, and literature, and often photographs were taken of the production activities and of the houses. With only one exception, all companies and organizations willingly granted interviews and were most generous with their help.

Upon completion of the field survey, the process of interpretation and analysis began, and it was supplemented by research into general aspects of management, design, procurement, production, and marketing. Heavenrich prepared an extensive summary report of his field survey which served as the nucleus around which much of the later writing was done. At the same time, the data which he and others had collected were put into shape for tabulation.

This involved the use of a specialized analysis form, the character of which was determined by a general study of the material available and the lines of reasoning to be followed. A number of student assistants were put to work assembling this information from the survey reports and from other material available in the Foundation files. This analysis form is reproduced here in full.

Analysis Form

MANAGEMENT

1. Staff of over 15 persons indicated? Yes _____ No _____
2. Company: number years in the business _____
3. Key personnel (a) Number years in the business _____
   (b) Background _____
4. Financing: public stock issue _____ private capital _____ other _____
5. Name of parent, subsidiary, or affiliated organizations for:
   Producing or purchasing raw material _____
   Licensing (indicate relationship) (parent or subsid.) _____
   Manufacturing _____
   Selling _____
   Financing _____
   Other (specify) _____
6. Influence of public opinion on design _____
   A. Original design generally conventional? Yes _____ No _____
   B. Later designs more conventional _____ less conventional _____
7. Extent of reliance on, or deference to, existing building material distribution methods: components not prefabricated for this reason:
   A. Floors _____ C. Roofing _____
   B. Plumbing _____ D. Other (specify) _____
8. Influence of banking organizations: trouble _____ help _____ list _____
9. Influence of government agencies: trouble _____ help _____ list _____
10. Influence of building codes: design concessions, list _____
11. Proof of soundness required: Yes _____ No _____
12. Having difficulty in pioneering new design: great _____ some _____ little _____
13. Union organization:
    Closed shop _____ Open shop _____ Union shop _____
    AFL _____ CIO _____ Other _____
    Title(s) _____
14. Effect of union organization on company and product:
    As expected _____ Good _____ Bad _____
    Specify _____

15. Conventional builders in area interested in dealerships? Yes _____ No _____
16. Public relations and/or advertising counseling hired? Yes _____ No _____
17. Advertising done: none _____ display _____ other (specify) _____
18. Comments on PHMI: favorable _____ unfavorable _____ (specify) _____
_____
19. Staff engaged in market research? Yes _____ No _____
20. Research or development done by: special staff _____ part-time by regular staff _____ nobody _____
21. Nature of research or development activity by company:
_____
_____
_____
_____
22. Research or development projects suggested for Bemis or other
_____
_____
_____
_____
_____
_____
23. New models regularly introduced? Yes _____ No _____ Specify basis _____
24. Competition regarded as outstanding: name _____
25. Competition regarded as not being "on the right track": name _____
26. General attitude: confident _____
hesitant _____
speculative _____

DESIGN

1. Classification
   A. Chief materials employed in structure
      1. wood 2. steel 3. concrete 4. aluminum 5. other _____
   B. Structural system
      1. frame assembly
      2. frame panels
      3. stressed skin panels
      4. stressed skin panels preassembled into large units
      5. solid panels
      6. monolithic
   C. Modular scheme
      1. none _____ 2. module size _____ 3. mfg. unit size _____
   D. Architecture
      1. number stories _____ 2. treatment
         traditional: good fair poor
         modern: good fair poor
      3. comment: _____
      _____
2. Foundation
   A. Basement: 1. yes 2. no 3. optional
   B. Support: 1. piers 2. continuous walls 3. other _____
3. Floors
   A. Structure
      1. frame assembly
      2. frame panels
      3. stressed skin panels
      4. solid panels
      5. monolithic

B. Details

	Material	*Size and Spacing*	*Application*[1]	*Field or Shop*
1. frame members				
2. subfloor				
3. insulation				
4. vapor barrier				
5. finish floor				

C. Joint type
1. butt 2. spline 3. m & f 4. interlocking 5. other _____

D. Comment: _____

4. Walls
A. Structure
1. frame assembly _____ 2. frame panels _____
3. stressed skin panels _____ 4. solid panels _____
5. monolithic _____

B. Details—walls

	Material	*Size and Spacing*	*Application*	*Field or Shop*
1. frame members				
2. exterior				
3. finish				
4. interior				
5. finish				
6. insulation				
7. vapor barrier				
8. casings (opening)				
9. frames				
10. sash				
11. door				
12. trim				

C. Details—partitions

1. frame members				
2. surface elements				
3. finish				

D. Joint type
1. butt 2. batten 3. spline 4. m & f 5. interlocking 6. other _____

E. Comment: _____

5. Ceiling
A. Structure
1. frame assembly 2. frame panels 3. stressed skin panels 4. solid panels
5. monolithic

[1] Glue and nail, electronic gluing, hot-press gluing, cold-press gluing, welding, riveting, spraying, other.

B. Details

	Material	*Size and Spacing*	*Application*	*Field or Shop*
1. frame members				
2. ceiling				
3. finish				
4. insulation				
5. vapor barrier				
6. cove molding				

C. Joint type

1. butt 2. batten 3. spline 4. m & f 5. interlocking 6. other _____

D. Comment: _____

6. Roof

A. Structure

1. frame assembly _____ 2. frame panels _____ 3. stressed skin panels _____
4. solid panels _____ 5. monolithic _____
   (a) truss _____ (b) number of sections in truss _____

B. Details

	Material	*Size and Spacing*	*Application*	*Field or Shop*
1. frame members				
2. sheathing or surface				
3. insulation				
4. roofing				
5. ventilation				

C. Joint type

1. butt 2. batten 3. spline 4. m & f 5. interlocking 6. other _____

D. Comment: _____

7. Gable-end panels

A. Separate panel? ____ B. Continuation of end walls? ____ C. Ventilation
   1. wood louvers
   2. metal louvers

8. Miscellaneous

A. Acoustical property comments _____
B. Rough window area _____
C. Weatherstripping (or similar action) _____
D. Ventilation in wall _____
E. Forced ventilation through attic _____
F. Lighting comments _____

9. Plumbing

A. Standard and specified layout? _____ B. Back to back? _____
C. Prefabrication
   1. precut?
   2. preassembled:
      (a) stacks and vents _____ _____
      (b) supply lines _____ _____
      (c) waste lines _____ _____

3. incorporated into panels? 4. fixtures connected?

D. Size of hot-water heater? _____ furnished? _____

E. Laundry tray furnished? _____

10. Heating

A. Standard and specified layout?

B. Basic type heat

1. gravity warm air 2. forced warm air 3. radiant (describe) _____

4. other _____

C. Preassembled

1. ductwork _____ 2. stack _____

11. Wiring

A. Standard and specified layout?

B. Prefabrication

1. precut 2. fish wires in panels 3. preinstalled in panels 4. lead wiring preassembled 5. wall outlets cut 6. wall outlets placed

12. Built-in furniture

A. Kitchen sink cabinet B. Other kitchen cabinets C. Dining tables

D. Drawer space ____ where _____ E. Storagewalls ____ where _____

F. Other _____

13. Garages

A. Manufactured

B. Part of package

14. Space arrangement (sq. ft.)

Kitchen	_____	_____	_____	_____	_____
Dining	_____	_____	_____	_____	_____
Living	_____	_____	_____	_____	_____
M Bedroom	_____	_____	_____	_____	_____
2 Bedroom	_____	_____	_____	_____	_____
3 Bedroom	_____	_____	_____	_____	_____
Closets	_____	_____	_____	_____	_____
Storage (other)	_____	_____	_____	_____	_____
Utility	_____	_____	_____	_____	_____
Covered porch	_____	_____	_____	_____	_____

15. Models and quality standards

A. Number of quality standards _____

B. Number basic design standards _____

C. Number of architectural styles _____

D. Number of basic floor plan variations _____

lefts and rights? _____

E. Number of different kinds of panels manufactured _____

1. floor _____ 2. wall and partition _____ 3. ceiling _____ 4. roof _____

16. Flexibility

A. Are panels interchangeable for expansion or repair after erection?

1. readily _____ 2. not easily _____ 3. impossible _____

B. Does literature emphasize possibility of adding rooms or wings? _____

C. Does plan attempt movable interior partitions? _____

17. Design developments by prefabricator, past _____

_____

_____

_____

18. Principles or theories governing design practices, as advanced by prefabricator_____

PRODUCTION AND PROCUREMENT

1. Plant
   - A. Number of plants _____
   - B. Size of plant visited (sq. ft.) _____ Built for the purpose _____
     Built _____ Building _____ No. _____
   - C. Number of men employed at time of visit _____
   - D. Number of men employed at capacity production _____
   - E. Comment on warehouse space _____
   - F. Ground acreage _____
2. Materials (converted) procurement
   - A. Lumber _____
   - B. Plywood _____
   - C. Sheetrock _____
   - D. Insulation _____
   - E. Other _____
3. Fabrication process
   - A. Materials preparation and handling
     1. cutoff (specify material) _____
     2. pickling or washing _____
     3. dipping _____
     4. sticking _____
     5. mixing _____
     6. stamping (specify parts) _____
     7. bending _____
     8. handling _____
        - (a) hyster _____
        - (b) carrier _____
        - (c) roller lines _____
        - (d) hand _____
        - (e) carts _____
        - (f) conveyer (overhead) _____
   - B. Subassembly operations
     1. skin _____
     2. framing members _____
     3. sash and door into frames and casing _____
     4. steel reinforcement _____
     5. core laminating _____
   - C. Assembly operations in plant: job-lot order: station to station: mass production:
     1. assembly tables
        - (a) machinery _____
        - (b) jigs _____ type _____
        - (c) molds _____ type _____

2. sizing operations on panels _____
3. conveyer line used
   (a) monorail _____
   (b) rollers _____
   (c) dollies _____
   (d) carts _____
   (e) hand _____
4. further assembly in plant _____
   _____
5. warehouse assembly points _____

D. Storage of manufactured items
   1. by type of panel 2. by houses 3. no storage

E. Manufacture of other items

	Type	*Quantity*	*Sold to Market as Well*
Sash			
Door			
Trim			
Cabinets			
Other			

4. Finished articles jobbed with house (indicate savings represented, price, if given) (also, Regularly, "R", Optional, "O", supplied)

Flooring _____	Stoves _____
Furnaces _____	Refrigerator _____
Screens _____	Hot-water heater _____
Storms _____	Plumbing fixtures _____
Roofing _____	Plumbing _____
Cabinets (kitchen sink) _____	Wiring _____
Cabinets (others) _____	

5. Estimates of manufacturing costs
   Plant _____
   Material _____
   Labor _____
   Overhead _____
   Others _____
6. Output, as of _____ Number produced, to date _____
   Number per week capacity _____ Estimated production _____
   Number per week producing _____
7. Production ideas contemplated _____
   _____
   _____
   _____

MARKETING

1. Cost

	$	*Sq. Ft.*
A. Package costs		

	$	Sq. Ft.
B. Estimated turnkey job cost		

C. Cost of selling
   1. company standard, dealer's profit
   2. dealer's profit, in practice
   3. cost of selling package to dealer

2. Method of distribution
   A. Factory to consumer
      1. direct sale
      2. erect for consumer
   B. Factory to dealer to consumer
   C. Factory to dealer-erector to consumer
   D. Factory to lumber yard to contractor to consumer
   E. Factory to lumber yard to consumer
   F. Factory to distributor (i.e. manufacturer's agent) to contractors of lumber yards to consumer
   G. Factory to: other

3. Origin of dealer
   A. Operative builders C. Lumber yards E. Real estate subdivider
   B. Contractors D. Real estate brokers F. A "financially responsible party"
   G. Other

4. Other services provided by dealer: A. Furnishings B. Architectural C. Real estate
5. Number of dealers
6. Adding dealers?
7. Dealer training
8. Franchises
   A. Contract? B. Exclusive?
9. Size of area of first level of distribution
10. Quotas indicated
11. Engineering aid to dealers from prefabricator
   A. Field erection supt. B. Detailing for individual orders or group orders
12. Shipping
   A. Cube
      1. houses per truck 2. houses per RR car
   B. Weight of package
   C. Cost of shipping (incl. packing)
   D. % of shipment
      1. truck 2. rail
   E. Radius
   F. Loading
      1. by hand 2. individual panels by hoist
      3. "package" by hoist
13. Erection
   A. Man-hours to "shell-in" house
   B. Man-hours to complete house
   C. Field equipment or special mechanisms necessary

D. Crew training done _____

E. Complexity, and skill required of crew _____

Comments: _____

_____

_____

14. Adaptable to:
    A. Individual erections _____
    B. Group erections 1. large 2. medium 3. small
15. Market
    A. Presently at: _____
    B. Aiming at: _____
    C. Areas of sales:
        1. rural
        2. rural non-farm
        3. urban small
        4. suburban
        5. urban medium
        6. urban large
    D. Company sells by:
        1. groups _____ 2. individual orders _____
16. Servicing on house provided _____
17. Guarantee given on house _____
18. Comments on dealer purchase financing
    A. Problem B. Not a problem
19. Dealer financing service provided
    A. Direct loans arranged from dealership _____
    B. Plans submitted to finance institutions for preapproval _____
    _____
    C. Indicate mortgage processing period cut down by dealer expediting methods
    _____
20. Government help
    A. RFC loans _____
    B. FHA approval
        1. nationally 2. locally 3. comments _____
        _____
    C. Surplus war plant _____
    D. Market guarantee _____
21. Export plans
    A. No interest _____ C. Definite plans _____
    B. Interested _____ D. Have exported _____

From the analysis form, the detailed data on the 125 companies which make up the substance of this study were inserted on a large chart (measuring 3′ × 12′), by means of a system of code numbering which expressed in simple form many variables in the data. This large chart made it a simple matter to tabulate information regarding any item in the analysis form or any company in the survey. Had the prefabrication industry been stabilized, it might have been valuable to reproduce such a chart, in simplified form, for general public use. Under the circumstances, however, it was not judged reasonable to do this.

For the purposes of writing this study, information on a number of specific points was taken from the chart on specially prepared summary sheets. The tabular material appearing in Chapter 7 in the text was, in turn, prepared from these summary sheets. Data were also charted and tabulated on 190 points of general information bearing on management, design, procurement, production, and marketing. Information on non-structural points was ordinarily not so complete as that on construction, and it often needed careful and subjective analysis before it could be recorded with any degree of accuracy.

Some companies produced more than one design; others were merely patent-holders or promoters and not producers and marketers; still others produced houses but did not themselves do the marketing; such circumstances complicated statistical analysis. There were the further complications of changes made after the period of survey, of new designs introduced, and of companies going out of existence. In general, however, it was felt that reliance could be placed upon the tabular material used in the text since it was carefully checked and accurate in its general nature.

Where specific information regarding individual companies was selected for discussion in the text, however, a further check was made, and unless there was corroboration in the form of published material or ready demonstration, each reference to an individual company was sent to that company for approval and comment. This was done even when the company had given general consent for the use of such material at the time of the original interview, and in many cases this later check was the source of useful later information.

Appendix B

COMPANIES AND PEOPLE VISITED

Acorn Houses, Inc., 53 State St., Boston 9, Mass.
Adirondack Log Cabin Co., Inc., 143 E. 45th St., New York 17, N. Y.
Admiral Homes, Inc., 149 Water St., West Newton, Pa.
Aladdin Co., The, Bay City, Mich.
Allied-Hodgson Housing Corp., Langhorne, Pa.
American Fabricators, Inc., Pine Bluff, Ark.
American Houses, Inc., 165 W. 46th St., New York 19, N. Y.
American Lumber Co., Inc., 25–47 Borden Ave., Long Island City 1, N. Y.
American Type Founders, 108 E. 25th St., New York, N. Y.
Anchorage Homes, Inc., Westfield, Mass.
Arlington Homes Mfg. Corporation, 500 N. Stanwood Rd., Columbus, O.

Barrett & Hilp, 918 Harrison St., San Francisco, Calif.
Benton Building Company (The Housemart, Inc.), 18320 Lanken Ave., Cleveland 19, O.
Better Living, Inc., 1659 De Kalb, Atlanta, Ga.
Birdsall, Gregg, & Assoc. (Adequate Housing, Inc.), 62 William St., New York, N. Y.
Brady Construction Co., 707 Spokane St., Seattle, Wash.
Brennan & Harrington, Lower Huntington Rd., Ft. Wayne, Ind.
Brown, Keith, Building Supply, 1450 Tile Rd., Salem, Ore.
Bruscino Builders and Prefabricators, 17309 Madison Ave., Lakewood, O.
Buffelen Lumber and Manufacturing Co., Tacoma, Wash.
Burns, Fritz B., Research Division of Housing, Los Angeles, Calif.
Butler Manufacturing Company, 1283 Eastern Ave., Kansas City 3, Mo.
Byrne Organization, Inc., 2607 Connecticut Ave., Washington 6, D. C.

California Prefab Corp., 5301 Valley Blvd., Los Angeles, Calif.
Capital Prefabricators, Inc., P. O. Box 821, Austin, Tex.
Carleton Lumber Co., 2008 N. Interstate, Portland, Ore.
Celotex Corporation, The, 120 S. La Salle St., Chicago 3, Ill.
Centrifugal & Mechanical Industries, Inc., 3600 S. Second St., St. Louis 18, Mo.
Chicago Chamber of Commerce, Chicago, Ill.
Chicago Vitreous Enamel Product Co., Cicero, Ill.
Clements Corporation, The, Southport, Conn.

Cleveland Chamber of Commerce, Cleveland, O.
Consolidated Vultee Aircraft Corporation (Southern California Homes), San Diego, Calif.
Crawford Corporation, 1901–2029 N. Third St., Baton Rouge, La.
Currier Lumber Co., 17507 Van Dyke, Detroit, Mich.

Dade Bros., Mineola, L. I., N. Y.
Defoe Shipbuilding Co., Bay City, Mich.
Dickinson, R. C., Co., Inc., Alviso Rd., Santa Clara, Calif.
Douglas Aircraft Co., Inc., Santa Monica, Calif.
Douglas Fir Plywood Association, Tacoma Bldg., Tacoma, Wash.
Drycemble Corp., 700 Cathedral St., Baltimore, Md.
Durabilt Homes Co., 520 Security Bldg., Denver, Colo.

Eastern Fabricators, Inc., 123 S. Broad St., Philadelphia, Pa.
Economy Portable Housing Company, West Chicago, Ill.
Eddy Shipbuilding Corporation, Bay City, Mich.

FHA, Washington 25, D. C.
Fabcrete of America, Inc., Bexley, O.
Far West Sales & Engineering Co., Tacoma, Wash.
Field Detroit Co., Birmingham, Mich.
Ford, Ivon R., Inc., McDonough, N. Y.
Forest City Material Co., The, 17903 St. Clair Ave., Cleveland 10, O.
Fox Metal Products Corporation, 1620 Blake St., Denver 2, Colo.
Fuller Houses, Inc., 420 West Douglas, Wichita 2, Kan.

Gamel, Inc., 174 Carroll St., Sunnyvale, Calif.
Geiger, Ervin, Route 4, Albion, Ind.
General Building Units, Dayton, O.
General Homes, Inc., Columbus, O.
General Houses, Inc., Chicago Daily News Bldg., Chicago 6, Ill.
General Industries, Inc., 3033 Wayne Trace, Fort Wayne 5, Ind.
General Panel Corporation, Graybar Bldg., New York, N. Y.
General Panel Corporation of California, Inc., 1101 W. Victory Blvd., Burbank, Calif.
General Plywood Corporation, Louisville 12, Ky.
Getzel Woodwork Co., 2712 S. 28th St., Milwaukee, Wis.
Goldsmith Metal Lath Co., Chickering and B. & O. R. R. (Winton Place), Cincinnati, O.
Gould Industries, Incorporated, 450 Sala Ave., Westwego, La.
Green Lumber Company, The, Laurel, Miss.
Green's Ready-Built Homes, 1221 Eighteenth Ave., Rockford, Ill.
Gunnison Homes, Inc., New Albany, Ind.
Gunnison Institute, New Albany, Ind.

HHFA (then NHA), Washington 25, D. C.
Hamill and Jones, 3029 Exposition Place, Los Angeles 16, Calif.
Harman, William H., Corporation, Wilmington 99, Del.
Harnischfeger Corporation, 100 Lake St., Port Washington, Wis.

Hayward Lumber and Investment Co., Los Angeles 53, Calif.
Higgins Industries, Inc., New Orleans 19, La.
Hodgson, E. F., Co., 393 Boylston St., Boston 16, Mass.
Home Builders Corp., Atlanta, Ga.
Home Corp. of America, Inc., DeKalb, Ill.
HomeOla Corporation, The, 9 S. Clinton St., Chicago 6, Ill.
Horsley Structures, Inc., Eugene, Ore.
Housing Research Corporation, 651 Boylston St., Boston 16, Mass.
Houston Ready-Cut House Co., Polk Ave., Houston, Tex.
Hudson, John L., Co., 8401 S. E. 70th Ave., Portland 6, Ore.
Huston Homes, 726 Beatie St., Oakland, Calif.

Iffinger, H. W., 680 Fifth Ave., New York, N. Y.
Independent Lumber Co., Nottingham Rd., Cleveland, O.
Ingersoll Steel Division, Borg-Warner Corporation, 310 S. Mich. Ave., Chicago 4, Ill.
Insulrock Homes Corp., 105 W. Verdugo Ave., Burbank, Calif.
Interlocking Walls Corporation, 3974 Wilshire Blvd., Los Angeles, Calif.

Jaeger Housing System, 221 E. Walton Rd., Pontiac, Mich.
Johnson Quality Homes, Inc., 270 41st St., Brooklyn 32, N. Y.
Juul Steel Houses, Sheboygan, Wis.

Kaiser Community Homes, 5555 W. Manchester Ave., Los Angeles, Calif.
Kashner-Bender, Inc., Pasadena, Calif.
Kolb Prefabricated Buildings, 250 W. 57th St., New York, N. Y.

Lifetime Building, Inc., 220 N. Main St., Tulsa, Okla.
Lincoln Houses Corporation, 1 E. 54th St., New York 22, N. Y.
Lincoln Lumber Co., 9025 G St., Oakland 3, Calif.
Lindsay, Claude T., Inc., Decoto, Calif.
Los Angeles Chamber of Commerce, Los Angeles, Calif.
Lustron Corporation, 4200 E. 5th St., Columbus, O.

Merriam & Twachtman, Fidelity Philadelphia Trust Bldg., Broad St., Philadelphia, Pa.
Metal Homes Company, 4041 Goodwin Ave., Los Angeles 26, Calif.
Mifflinburg Body Works (American Prebilt Homes Div.), 200 Madison Ave., New York, N. Y.
Modelow Co., 3415 Carr Place, Seattle, Wash.
Modern Standardized Buildings Co., 320 N. 4th St., St. Louis, Mo.

NAHM, 1028 Connecticut Ave., N. W., Washington 6, D. C.
NHA (now HHFA), Washington 25, D. C.
National Homes Corporation, Lafayette, Ind.
New Century Homes, Clinton, Ind.
Nichols & Cox, Grand Rapids, Mich.
Nicoll & Co., 1212 19th St., Oakland, Calif.
Normack, Inc., 1007 S. Grand Ave., Los Angeles 15, Calif.
Northwest Fabricators, Inc., Albany, Ore.
Northwest Syndicate, Inc., 711 St. Helens Ave., Tacoma, Wash.
Nygaard Builders, Inc., Tacoma, Wash.

PHMI, 908 20th St., N. W., Washington 6, D. C.
Pacific Coast Building Officials Conference, 124 W. 4th St., Los Angeles, Calif.
Pease Woodwork Company, Inc., Blue Rock and Turrill Sts., Cincinnati 23, O.
Peerless Housing Company, Inc., 300 4th Ave., New York 10, N. Y.
Plainfield Lumber & Supply Co., Plainfield, N. J.
Ply-wel Industries, 4805 Tidewater Ave., Oakland, Calif.
Porete Mfg. Co., Porete Ave., North Arlington, N. J.
Prebilt Co., The, Revere Beach Parkway, Revere, Mass.
Pre-Bilt Homes Co., Inc., 2901 S. San Pedro St., Los Angeles 11, Calif.
Precision Builders, 3116 S. Oakes St., Tacoma, Wash.
Precision-Built Homes Corporation, Trenton, N. J.
Precision Homes Company, 1101 East Channel St., Stockton, Calif.
Precision Housing Corp., 6619 Pearl Rd., Parma Heights, O.
Pre-Fab Industries Corporation, 160 S. Main St., South Bend, Ind.
Prefabricated Home Builders, 4118 Crenshaw Blvd., Los Angeles 43, Calif.
Prefabricated Home Manufacturers and Dealers of California, 151 South Broadway, Los Angeles, Calif.
Prefabricated Homes, Illuminating Publishing Co., Inc., 114 E. 32nd St., New York, N. Y.
Prefabricated Products Co., Inc., West Marginal Way & Iowa, Seattle, Wash.
Prefabrication Engineering Co. (now Robert F. Johnson and Associates), 734 N. E. 55th Ave., Portland 13, Ore.
Production Line Structures, 941 N. La Cienega Blvd., Los Angeles 46, Calif.
Purdue Research Foundation, Lafayette, Ind.

Red-E-Bilt Homes, 1947 Dennison Ave., Oakland, Calif.
Reid, Maxwell, 959 33rd St., Oakland, Calif.
Reliance Homes, Inc., Lester, Pa.
Reynolds Metals Company, Alumi-drome Div., 2015 S. Ninth St., Louisville 1, Ky.
Rieger, H. R., Co., The, 4634 Parrish St., Philadelphia, Pa.

Sanford, Inc., Avon Lake, O.
Scott Lumber Company, 1112 Chapline St., Wheeling, W. Va.
Seaboard Ready-Built Homes, 330 Walnut St., Philadelphia 6, Pa.
Shelter Industries, Inc., 630 Fifth Ave., New York, N. Y.
Soulé Steel Company, 1750 Army St., San Francisco 24, Calif.
Southern Mill & Manufacturing Co., 525 S. Troost Ave., Tulsa, Okla.
Southwest American Homes, Inc., 2005 Canal St., Houston, Tex.
Standard Fireproof Construction Co., 39 Lewis Wharf, Boston, Mass.
Standard Prefabricating Co., Inc., 1702 Hoge Bldg., Seattle 4, Wash.
Steelcraft Manufacturing Company, The, Rossmoyne (Cincinnati), O.
Stout Houses, Inc., Stephenson Bldg., Detroit, Mich.
Strathmoor Company, 14000 Grand River Blvd., Detroit, Mich.
Structures, Inc., 128 N. Wells St., Chicago 6, Ill.

Tacoma Lumber Fabricating Co., Tacoma, Wash.
Texas Housing Co., 9003 Denton Drive, Dallas 9, Tex.
Timber Structures, Inc., N. W. Yeon Ave. at 29th, Portland 8, Ore.
Tovell Construction Co., 403 W. Monument St., Baltimore, Md.

Unicon of Ohio, Inc., 1783 E. 11th St., Cleveland, O.
U. S. Department of Commerce, Office of Technical Services, Washington, D. C.
U. S. Forest Products Laboratory, Madison, Wis.
U. S. Homes, Inc., Marietta, Ga.
United States Housing Company, Sheboygan Falls, Wis.
U. S. Housing Materials Corporation, The, 10815 Watertown Plank Rd., Milwaukee, Wis.
U. S. Prefab Corporation, Division St., Patchogue, L. I., N. Y.
Utley-Lincoln System, Inc., Royal Oak, Mich.

Vacuum Concrete, Inc., 4210 Sansom St., Philadelphia 4, Pa.

Wadsworth Building Company, Inc., 5630 W. 80th St., Overland Park, Kan.
Western Wood Fabricating Co., Inc., Route #1, Box 294 A, Bellevue, Wash.
Wickes Engineering and Construction Company, 12th St. and Ferry Ave., Camden, N. J.
Winner Mfg. Co., Trenton 3, N. J.
Wingfoot Homes, Inc., Akron 16, O.

PREFABRICATORS MENTIONED BUT NOT VISITED

Airform Construction, 5927 Franklin Ave., Los Angeles 28, Calif.
American Rolling Mills Company, Middletown, O.

Bralei Homes, Inc., North Little Rock, Ark.

Detroit Steel Products Company (Fenestra Building Panel Division), 1210 E. Ferry St., Buffalo 11, N. Y.

General Fabricators, Inc., Attica, Ind.
General Housing Corporation, Seattle, Wash.
General Timber Service, Inc., First National Bank Bldg., St. Paul 1, Minn.
Gordon-Van Tine Company, Davenport, Ia.

Hauserman, E. F., Company, Cleveland 5, O.
Hayes Econocrete Corporation of America, 112 W. 9th St., Los Angeles 15, Calif.
Home Building Corp., P. O. Box 370, 303 North Park, Sedalia, Mo.

Ibec Housing Corporation, 30 Rockefeller Plaza, New York 20, N. Y.

LeTourneau, R. G., Inc., Longview, Tex.
Lindsay Corporation, Melrose Park, Ill.
Lockwall Houses, Inc., 65 Broadway, New York, N. Y.

Pacific Systems Homes, Inc., 5800 S. Boyle Ave., Los Angeles, Calif.
Page and Hill Co., Plymouth Bldg., Minneapolis, Minn.
Palace Corporation, Flint, Mich.

Ratio Structures (Paul Lester Wiener), 33 W. 42nd St., New York 18, N. Y.

Sears, Roebuck and Co., Newark, N. J.
Solar Homes Co., 17 Elliott St., Brattleboro, Vt.
Southern California Homes, Inc., 4900 Cecelia St., Bell, Calif.
Standard Fabrication Inc., 721 N. Mich. Ave., Chicago, Ill.
Standard Houses Corp., Anderson, Ind.
Stran-Steel Division, Great Lakes Steel Corporation, Penobscot Bldg., Detroit 26, Mich.

United States Plywood Corp., 55 W. 44th St., New York, N. Y.

Appendix C

LISTS OF PREFABRICATORS

Date	*Source*	*Contents*
May 23, 1938	Bemis Industries, Inc., Modular Division	36 manufacturers or builders ready to quote prices on complete houses.
August 1938	U. S. Department of Commerce, Bureau of Foreign and Domestic Commerce, Forest Products Division	A partial list of firms (23) engaged in the manufacture of wood prefabricated buildings.
August 21, 1939	U. S. Department of Commerce, National Bureau of Standards	41 concerns interested in metal house construction.
September 1940	Central Housing Committee on Economics and Statistics	41 prefabricators, from a number of sources including catalogues and letters from the companies.
February 3, 1942	Central Housing Committee on Research, Design and Construction, Sub-Committee on Prefabrication	204 manufacturers of prefabricated houses, also systems of prefabrication.
February 1942	*The Architectural Forum*	103 recognized prefabricators active in 1941.
April 1943	*The Architectural Forum*	Directory of 71 wartime prefabricators.
October 5, 1944	*Iron Age*	43 major prefabricators using wood, plywood, gypsum board, and similar materials; 12 using steel.
April 1, 1945	NHA, Office of the Administrator, Technical Division	95 manufacturers of prefabricated houses, also systems of prefabrication
March 1, 1946	*Fortune*, April 1946	74 prefabricators listed from the best sources available.
May 27, 1946	Department of Commerce, Construction Division	215 concerns engaged in some phase of prefabrication at a time of great industrial changes.

Date	*Source*	*Contents*
November 1, 1946	NHA	195 prefabricators qualified by NHA for priorities assistance for at least one model.
1947	The Housing Institute, Inc.	87 prefabricators and systems.
January 1, 1947	NHA	280 prefabricators qualified by NHA for priorities.
February 15, 1947	FHA Underwriting Division, *Technical Circular*, no. 11	149 special structural systems of prefabrication and site techniques for which FHA *Engineering Bulletins* have been issued. Revised July 1, 1948, to include 191 companies.
May 1947	Department of Commerce, Construction Division, Office of Domestic Commerce	276 manufacturers of prefabricated houses.
January 1, 1948	HHFA	82 prefabricators reported to be in operation as of January 1, 1948.

Appendix D

ANNOTATED BIBLIOGRAPHY

I. Books and Pamphlets

Anthony, Hugh. *Houses; Permanence and Prefabrication.* London: Pleiades Books, Ltd., 1945. 64 pp.

Brief general discussion of housebuilding, and prefabrication in particular, as related to British postwar problems. Chiefly interested in the questions of permanence, standardization, and flexibility and how these affect cost. Well illustrated.

Architectural Forum, The. The Integrated House—a new approach to cost reduction. [New York]: Time Inc., 1937.

Argues against complete prefabrication by one producer and for integration in building as a whole which is said to involve three principles: modular design, interchangeable elements, and multipurpose parts. Discusses developments along these lines. Reprinted from *The Architectural Forum,* April 1937.

Architectural Record. When Better Homes Are Built. . . . New York: F. W. Dodge Corporation, 1945 [?]. 36 pp.

A number of wartime articles and editorials about postwar housing, especially prefabrication, reprinted from *Architectural Record.* Technical advances, distribution methods, and the potential market are discussed. List of prefabricators.

Bemis, Albert Farwell, and John Burchard, 2nd. *The Evolving House.* Cambridge, Mass.: The Technology Press, Massachusetts Institute of Technology, 1936. 3 volumes. Vol. I, *A History of the Home;* Vol. II, *The Economics of Shelter;* Vol. III, *Rational Design.*

A major work which provides a comprehensive survey of housing from several aspects. Volume III gives a detailed exposition of the theory and application of modular design. Descriptions, illustrations, and evaluations of some 100 European and American prefabrication systems are included in an important supplement to this volume. Bibliography.

Bruce, Alfred, and Harold Sandbank. *A History of Prefabrication.* Raritan, N. J.: The John B. Pierce Foundation, 1943. 80 pp.

Very good review of American prefabrication experience since the turn of the century expressed more as a summary of trends than as analyses of particular systems. Based on extensive research by the Pierce Foundation. Well illustrated. Directory of 26 wartime prefabricators. Bibliography. Appeared, in main, as a series of articles in *The Architectural Forum,* beginning December 1942.

Carr, A. L. *A Practical Guide to Prefabricated Houses.* New York: Harper & Brothers, 1947. 111 pp.

Pictures, plans, prices, and brief descriptions of the houses of 21 prefabricators, giving also a short account of their backgrounds and methods of operation. Directory of 250 prefabricators. Checklist for the buyer of a prefabricated house.

Fitch, James Marston. *American Building; The Forces That Shape It.* Boston: Houghton Mifflin Co., 1948. 382 pp.

An important study of the whole of American building in relation to the technical, political, social, and economic forces that have shaped it in the past and continue to do so today. Only a few pages are devoted specifically to prefabrication as such, but these provide an illuminating, if brief, commentary on relevant economic factors.

Gloag, John, and Grey Wornum. *House out of Factory.* London: George Allen & Unwin, Ltd., 1946. 144 pp., and plates.

Presents the case for prefabrication to the intelligent layman and technician. Brief survey of materials, structures, some 50 systems, and short discussion of standards, durability, and maintenance. Good illustrations. Main emphasis on British experience and problems.

Graff, Raymond K., Rudolph A. Matern, and Henry Lionel Williams. *The Prefabricated House; A Practical Guide for the Prospective Buyer.* Garden City, N. Y.: Doubleday & Co., Inc., 1947. 132 pp.

General advice to the layman on what to expect in buying a prefabricated house, what to look for, how to select and adopt a site, how to go about the purchase, and who and where the manufacturers are (183 are listed). Poses a good many helpful questions.

Great Britain, Committee for the Industrial and Scientific Provision of Housing. *Housing Production, or the Application of Quantity Production Technique to Building; Its Social, Commercial and Technical Possibilities and Requirements.* First Report of the Committee. London: 1943. 96 pp.

Poses the social, economic, and esthetic problems accompanying the industrialization of housing and suggests the form and functions of an organization to study them.

Great Britain, Committee for the Industrial and Scientific Provision of Housing. *Housing Production II, or the Application of Quantity Production Technique to Building; Some Technical History and Considerations.* Second Report of the Committee. London: 1943. 159 pp., bibliography, and appendices.

This extensive summary of American and European experience in prefabrication is an important study based on considerable research. No illustrations. Bibliography. Suggested research program. Tabular review of some 500 systems.

Harrison, D. Dex, J. M. Albery, M. W. Whiting. *A Survey of Prefabrication.* [London]: Ministry of Works, 1945.

Probably the best survey of prefabrication systems to date, from the design point of view. 300 case sheets present experience in 14 countries. Introductory text discusses history, methods of approach, materials, structures. Well illustrated and cross-indexed. Bibliography. A very valuable work.

McKennee, O. W., and the Staff of The Housing Institute, Inc. *Prefabs on Parade.* New York: The Housing Institute, Inc., 1948. 110 pp.

Pictures, plans, and brief descriptions of the houses of 57 prefabricators. List of 92 prefabricators and prefabricating systems. Directed primarily towards the prospective home owner.

Madge, John, ed. *Tomorrow's Houses; New Building Methods, Structures and Materials.* London: Pilot Press Ltd., 1946. 336 pp.

A collection of essays on various aspects of building which includes one on the AIROH house by Greville Collins and a good, but brief, outline of prefabrication by D. Dex Harrison. The latter deals with the development of the movement, materials, standardization, and flexibility in design. Another article gives rather comprehensive descriptions of five British postwar prefabrication systems.

Owsley, Roy H. *Municipal Regulation of Temporary Housing and Prefabricated Construction.* Chicago: American Municipal Association, 1946. 33 pp.

Outlines the problem and presents a number of representative code provisions to aid municipal officials in drafting ordinances and code amendments for their own localities.

Sheppard, Richard. *Prefabrication in Building.* London: The Architectural Press, 1946. 148 pp.

General statement of the aims, methods, and development of prefabrication. Some discussion of materials, structures, techniques. Very good descriptions of a number of British postwar systems. Well illustrated.

Twentieth Century Fund, Housing Committee. *American Housing; Problems and Prospects.* The factual findings by Miles L. Colean. The program by the Housing Committee. New York: The Twentieth Century Fund, 1944. 466 pp.

Excellent, thorough analysis in which is given a very brief but good description of the prefabrication industry, its operations, problems, and prospects, from a primarily economic point of view. A wealth of factual and interpretive material on the whole housebuilding industry.

U. S. Congress. Joint Committee on Housing, 80th Congress. *Hearings.* Washington: U. S. Government Printing Office, 1948.

Part 5 of the *Hearings* includes interesting testimony by several prefabricators on their current operations and the problems they have encountered. Some good case material.

U. S. Congress. Joint Committee on Housing, 80th Congress, Subcommittee on cost factors and cost reduction in housing. *The High Cost of Housing.* Washington: U. S. Government Printing Office, 1948. 185 pp.

The chapter on prefabrication gives a good picture of the industry's operations. The report also describes some large scale site operations and other cost reduction techniques. Contains much factual material. A useful study.

U. S. Department of Commerce. *Prefabricated Homes;* Commercial Standard

CS125-47. 2nd ed. Washington: U. S. Government Printing Office, 1947. 22 pp.

Sets forth a set of standards voluntarily adopted by the industry. This project was initiated by the Prefabricated Home Manufacturers' Institute.

U. S. Forest Products Laboratory, Forest Service, Department of Agriculture, in collaboration with the Technical Staff, Housing and Home Finance Agency. *Manual on Wood Construction for Prefabricated Houses.* Washington: U. S. Government Printing Office, 1947. 330 pp.

Very good comprehensive guide and reference work on construction techniques for wood prefabrication. Covers the properties of materials, their preparation, storage, and protection; machining, gluing, painting; joints and other design problems. Helpful to architects, engineers, builders, and contractors.

Yorke, F. R. S. *The Modern House.* London: The Architectural Press, 1934. 199 pp.

About two dozen prefabricated and experimental houses in a half-dozen countries are briefly described. A spotty survey of early experience.

Zucker, Paul, ed. *New Architecture and City Planning; A Symposium.* New York: Philosophical Library, Inc., 1944. 694 pp.

In the section on new materials and construction methods there are several authoritative articles about or related to prefabrication. They are brief, however, and do little more than outline their subjects.

II. Conference Proceedings

American-Soviet Building Conference, Proceedings. New York: Architects Committee of the National Council of American-Soviet Friendship in collaboration with *The Architectural Forum,* 1945. 206 pp. (Auspices of the Architects Committee of the National Council of American-Soviet Friendship in cooperation with the New York Chapter of the American Institute of Architects. Held in New York, May 5, 1945.)

A panel of American and Russian authorities discuss prefabrication in the United States and U.S.S.R., dealing with structures, materials, production techniques, transportation, costs, and other topics. Some facts, many opinions. An interesting symposium.

Second Ann Arbor Conference on Architectural Design and Practice, Papers. Ann Arbor, Mich.: University of Michigan, 1945. 52 pp. (Auspices of the College of Architecture and Design. Held at Ann Arbor, February 3 and 4, 1945.)

"Prefabrication," by George B. Brigham, Jr., is a brief report on two prefabrication research projects carried on at the University of Michigan, one on a system of modular panels, the other on a sectional house system.

Conference on Housing, Proceedings. Cambridge, Mass.: *The Technology Review,* XXXIX (July 1937). (Sponsored by the Massachusetts Institute of Technology. Held in Cambridge, June 7, 1937.)

"How Better Houses Will be Built; The Question Mark of Prefabrication," by John E. Burchard, gives a concise review of prefabrication experience, its disappointments, lessons, and promise.

House and Garden Symposium on Prefabrication. Reported in *House and Garden,* December 1935. (Sponsored by *House and Garden* Magazine. Held in New York, 1935.)

Some of the pioneers in the field discuss a number of topics that are still of interest: optimum life of a house, financing, modern design, prefinishing versus site finishing. Gives the flavor of early thought on these and other questions.

Yale-Life Conference on House Building Technics, Digest of Papers Presented. New York: Time Inc., 1939. Reported also in *The Architectural Forum,* March 1939. (Sponsored jointly by Yale University and *Life* Magazine. Held at Yale University, New Haven, Conn., January 31 and February 1, 1939.)

Summarizes 12 addresses on such subjects as standardization, materials, mobility, technical research. An unfortunately condensed presentation of some very good papers by leading men in the field. Of some value nonetheless.

III. Trade Association Material

Douglas Fir Plywood Association, Tacoma Building, Tacoma 2, Wash.:

How to Build a House Fast? The Answer is Prefabrication. 1941.

A booklet devoted to promoting prefabrication (with plywood). Well illustrated with pictures of plants, the erection process, and finished houses.

Construction Manual for Douglas Fir Plywood Dri-Bilt Houses. 1940.

Gives construction details and procedures. Walls, ceilings, and partitions are prefabricated in large panels. 2″ × 4″ framing. Reprinted from *Practical Builder,* February 1940.

Better Homes for More People through Prefabrication. 1946.

Brief description of prefabrication principles, practices, and problems. Illustrated with pictures of factory operations and finished houses.

The Portland Cement Association, 33 W. Grand St., Chicago, Ill.

Report on Survey of Concrete House Construction Systems. 1934.

A comprehensive and useful report giving brief written descriptions, together with photographs and drawings, of 84 systems of four basic types: precast unit; monolithic; stucco on steel or concrete frame; masonry. General introductory discussion and conclusion.

Prefabricated Home Manufacturers' Institute, 908 20th St., N.W., Washington 6, D. C.:

Modern Homes by Modern Methods, 1946.

Promotional booklet which outlines the advantages of prefabrication. Illustrated.

IV. Periodicals

The material on prefabrication which has appeared in periodicals is so voluminous that no attempt is made to list it here. For references, the following should be consulted:

Reader's Guide to Periodical Literature.

The Industrial Arts Index.

Art Index.

(In all the above, see "Houses, Prefabricated," also "Houses, Fabricated" or "Houses, Portable.")

Prefabricated Homes (*Basic Information Sources*). Washington: Office of Domestic Commerce, U. S. Department of Commerce, February 1948.

Prefabricated Structures, 1940–1944; A List of References. Edward S. Evans Transportation Research and U. S. Department of Agriculture Library, Washington, February 1945.

In addition, the following reference material may be obtained by written request:

Prefabricated Housing; Bibliography and Briefed Articles from Business, Technical, and Consumer Publications, 1927–1942. Newell-Emmett Co., 40 E. 34th St., New York, N. Y.

Lists of articles on prefabrication that have appeared in

The Architectural Forum (350 Fifth Ave., New York, N. Y.).

Architectural Record (119 W. 40th St., New York, N. Y.).

Progressive Architecture (330 W. 42nd St., New York, N. Y.).

Prefabrication was the trade paper of the industry. It was published until October 1949 by the Illumination Publishing Co., Inc., 114 E. 32nd St., New York, N. Y.

V. Other Sources

The Industrial Research and Development Division of the Office of Technical Services, U. S. Department of Commerce, has contracted for a number of special research projects involving new building materials, modular coordination, and prefabricated systems of construction. Reports of these projects are published from time to time and are available upon request from the Office of Technical Services, Department of Commerce, Washington, D. C.

The National Bureau of Standards has published a series of *Building Materials and Structures Reports* (BMS series), which give technical information on the engineering properties of various materials, structural elements, construction sys-

tems, and equipments used in housebuilding. Some of these *Reports* relate specifically to prefabrication. *Reports* may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

The Office of the Administrator, Housing and Home Finance Agency, publishes at frequent intervals a *Technical Bulletin* which contains articles on various house construction problems and reports of research projects sponsored by the HHFA. A number of *Technical Papers* relating to specific problems in housebuilding have also been published. *Technical Bulletins* and *Technical Papers* may be obtained from the Office of the Administrator, Washington, D. C.

The Federal Housing Administration, through its Underwriting Division, issues *Bulletins* which describe special systems of construction (most of them prefabricated) that have been approved by the FHA and outline the limitations with which these systems may be used. *Bulletins* are issued primarily for the guidance of local FHA offices in processing cases and are not available for general distribution from the FHA. They may be reproduced and distributed by the proponents of the system in question, however, as desired. *Technical Circular,* no. 11, July 1, 1948, gives a list of *Bulletins* and may be obtained from the Underwriting Division, Federal Housing Administration, Washington, D. C.

Insured Mortgage Portfolio, published quarterly by the FHA, contains occasional articles particularly related to prefabrication.

The FHA also issues administrative rulings governing its special insuring operations in connection with the manufacture of prefabricated houses.

The Prefabricated Home Manufacturers' Institute renders a very valuable service by gathering information about member companies, and, in so far as it is able, about non-member companies as well. It is the best source for statistical material concerning the industry, and its importance in this respect has increased as the amount of specialized government attention to prefabrication has decreased. It is now, for instance, the only source of production figures because the statistics on starts and completions compiled by the Bureau of Labor Statistics do not distinguish prefabricated from other houses.

The Bemis Foundation files on the various prefabricators, and other reference material on prefabrication, are available at the offices of the Foundation, Room 7-335, Massachusetts Institute of Technology, Cambridge, Mass.

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